MOTION PICTURE HANDBOOK

FOR MANAGERS AND OPERATORS

THIRD EDITION

by F. H. RICHARDSON

PUBLISHED BY
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NEW YORK

3rd edition
updated & enlarged

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A Guide for
MANAGERS AND OPERATORS
of MOTION PICTURE THEATRES

By F. H. RICHARDSON

THIRD EDITION

Published by
THE MOVING PICTURE WORLD
Pullman Building, 17 Madison Avenue
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Acknowledgement Is Hereby Made
to
Mr. B. M. SPENCER,
Attleboro, Mass.,
For the Drawings for a Large
Number of the Cuts in
This Handbook.

Author's Note

TO FIRST EDITION

THIS book is dedicated to the motion picture operator as a token of appreciation of the important part he plays in the presentation of the photoplay. That it may be helpful in hastening the day of perfect motion picture projection is the desire of the writer, and he trusts that a careful perusal of its pages may stir the ambition and increase the ability of every reader.

October, 1910.

F. H. Richardson

Publisher's Note

TO FIRST EDITION

THE remarkable vogue of the motion picture and the rapid strides it has made in public favor as an entertainment and educational factor have had their drawbacks. Chief among these has been the impossibility of securing a sufficient number of men with the necessary knowledge and experience to fill important positions.

THE MOVING PICTURE WORLD has, in no small measure, contributed to the success of the picture, and the articles in this book were written to give helpful information in regard to the many problems that may arise in connection with the duties of the manager and operator. With a few exceptions, the articles have already appeared in THE MOVING PICTURE WORLD, but they have been revised and amplified and are herewith presented in compact form to comply with popular request.

Mr. Richardson has avoided technical terms, and his plain language and matter-of-fact style bespeak for this book the same degree of popularity which attaches to the Operators' Column which he still conducts in the pages of

THE MOVING PICTURE WORLD.

October, 1910.

Author's Note

TO SECOND EDITION

LIKE the former edition, this book is dedicated to the moving picture operator, upon whose skill in the projection of the magnificent work of our modern producers so very much depends. Since the inception of the Projection Department of THE MOVING PICTURE WORLD and the publication of the first book rapid strides have been made in the perfection of projection. The author hopes and believes that this work will serve to even further advance and perfect projection to the end that the photoplay may become still more firmly fixed in the affections of the amusement-loving public.

F. H. Richardson

October 30, 1912.

Publisher's Note

TO SECOND EDITION

THE enormous increase in popularity of the motion picture during the past few years in all countries is one of the marvels of the day. The moving picture is now far in advance of all other forms of public entertainment among all classes and draws a daily patronage that is beyond belief.

In no other country, however, do the pictures have quite as good a hold on the public favor as in the United States. This is in great measure due to the enterprise and higher ideals of the film manufacturers in this country. It is also due in great measure to the care and attention given to programs, theater management and especially the projection of the pictures by the exhibitors throughout the United States and Canada.

The first edition of this work was published over two years since and has been of immense value and help to operators throughout the country. This edition has been greatly enlarged and will be found much more complete in every way. It will undoubtedly remain the standard work in its field for many years and is a worthy monument to its author's ability and painstaking effort.

CHALMERS PUBLISHING COMPANY.

November, 1912.

Author's Note

TO THIRD EDITION

AS in the case of the first and second editions, I believe it is but right and proper that this, my latest effort, should be dedicated to the moving picture operator, upon whose shoulders rest, in large degree, the welfare of the entire moving picture industry. The author has faith to believe that this book will be favorably received by the fraternity and trusts it will accomplish a large amount of good for all students of projection.

In order to do justice to the magnificent productions of today it is necessary that the moving picture operator have a wide range of knowledge and that he be capable of applying that knowledge in the best possible way. The day of guesswork in projection is past. The author feels that while this book will be of great aid to the moving picture operator, it will also indirectly be of equally great help to the producers and all others connected with the industry by reason of the fact that it is the finished product which is placed in the hands of the moving picture operator, who may either reproduce it on the screen as a magnificent spectacle or a shadowy, jumping travesty on the original.

November, 1915.

F H Richardson

Publisher's Note

TO THIRD EDITION

THERE is little to add by the Publishers in introducing this new edition. The first and second editions of this work were most complete and instructive at the time of their publication. Each edition was an improvement over the previous one, and this book much more than either of its predecessors not only reflects the wonderful progress and improvement in moving picture projection but points the way to still greater advancement.

The author has spent all of his time for many years in the study of projection, and we confidently believe this comprehensive work will meet with the unqualified approval of every reader.

CHALMERS PUBLISHING COMPANY.

December, 1915.

Go to your work each day as though it were your first day on a new job and you had to make good.

Polarity

IN order to have a comprehensive understanding of electrical action it is essential that the operator have a very clear and thorough understanding as to precisely what polarity means, and how it acts, because the whole superstructure of electrical action rests thereon.

The electric circuit with which the operator comes into contact consists of two wires—no more and no less. There may appear to be more, as, for instance, in a three-wire system, but, as a matter of fact, so far as electrical action be concerned, every electric circuit is composed of two wires, viz.: the positive and the negative, and it is the affinity these two wires (which represent the poles of the dynamo) have for each other which constitutes "polarity." There always has been and still is controversy between eminent theoretical electricians as to the exact nature of the action which takes place as between the positive and the negative wire. To avoid all confusion, however, we will lay aside technical questions and accept the common statement that current seeks always to flow from the positive to the negative. Having accepted this as the fact it may be further said that the inclination of the current to escape from the positive to the negative is similar to the efforts of steam to escape from the boiler into the open air. When steam escapes from the boiler to the open air it loses its pressure in the process. When electrical energy escapes from the positive to the negative it does exactly the same thing, and that is why it seeks to escape; also that is why it will perform work in the process of escaping. The pressure in the boiler will force the steam to the open air through the cylinder of an engine, moving the piston and thus performing work in the process. The electric current will perform work in the motor or the lamp, since it can get from positive to negative by so doing and thus lose its pressure. This electrical affinity is termed "polarity," and its strength, which may be much or little, is measured in volts.

And now let me make one point very clear. Electrical affinity or polarity only exists between the positive wire and the negative wire attached to the same dynamo or battery. There is absolutely no electrical affinity between the negative wire attached to one generator and the positive wire attached to another generator, unless the generators themselves are electrically coupled, as in the case of the three-wire system. You could set two generators running, side by side, each generating 500 volts, and touch the positive of one generator to the negative of the other machine without any effect whatever, but the instant you touch the positive of either one to the negative of the same machine there will be fireworks.

And now let us go a little further: The general idea is that current seeks to escape from the wires into the ground. *This is not true except in so far as the ground may offer a path from positive to negative.* If you could have a generator and wire system working at 5000 volts, or any other voltage, thoroughly and completely insulated (a condition never found in actual practice), you could stand with your bare feet on the wet ground and handle either wire of the circuit without any danger whatever, but the instant one of the wires develops current carrying connection with the ground and you stand on the ground and touch the other wire you get a shock, by reason of the fact that the current, leaping through your body into the earth and following the earth to the location of the ground on the opposite side, makes escape into the negative. If you happen to be holding the negative wire, that makes no difference, except that instead of escaping into your hands and passing through your body into the earth the current escapes through the ground at the positive into the earth, follows the earth to your body and up through your body to the negative.

In closing this topic let me repeat that the term polarity expresses the electrical difference between positive and negative.

How Electricity Is Generated

MORE and more it is becoming essential that the moving picture operator have a comprehensive knowledge of electrical action, not only as pertains directly to the projection arc circuit, but also as relates to dynamos and motors. An ever increasing number of moving picture theatres are installing either motor generator sets or mercury arc rectifiers for the changing of alternating current into direct

current, or else isolated light plants consisting of a dynamo driven by a gas, gasoline, kerosene or steam engine. The operator is usually the man who is expected to take charge of and operate these isolated plants, and most certainly it is a part of his duties to handle and take care of a motor generator set, or other device used for the rectifying of current. Therefore, I repeat, the up-to-date competent moving picture operator must have a very comprehensive knowledge of electrical action.

This, the third edition of my Handbook, is, like former editions, a work for practical men. In this book I shall, as I have in the past editions, pay a great deal more attention to practical things than to fine-spun theories and strictly technical correctness.

We do not know the precise nature of the force we call electricity. We do not know what it consists of. Its component parts have never been analyzed. We only know that it is a mighty force, which apparently has neither substance nor weight. It is a peculiar state, or condition, in and immediately surrounding a wire attached to a battery or generator which is not found in any wire not so attached.

We do, however, know how to handle this mysterious force, and bend it to our will. In fact, our knowledge of electrical action has become so complete that the mighty giant is as a child in our hands. We have chained it to the wheels of progress, and it has become a slave to mankind.

Electricity may be divided into three distinct classes, viz.: Static electricity, magnetism and electric current, meaning, by the latter. current which is generated by batteries or by an electric dynamo.

If you take a glass jar, of any convenient size, fill it two-thirds full of water, and then put in ordinary sal amoniac in proportion of a pound to the gallon of water, and in this solution suspend a piece of ordinary sheet copper, of considerable dimensions, and near to it but not touching suspend a piece of zinc, also of considerable dimensions, you will have the simplest form of what is known as an "electric battery." Now if you join the copper to the zinc by means of a piece of copper wire, current will flow between the two, or, more correctly speaking, from the copper to the zinc, the copper being positive and the zinc negative. A properly proportioned battery of this sort will generate about one volt pressure, and will put forth a considerable amperage while it lasts. It would be theoretically possible to construct and connect together

a sufficient number of batteries of this kind to operate a projection arc lamp, but, though theoretically possible, it would nevertheless be highly impractical. In practice the use of the battery is largely confined to the ringing of bells and buzzers, the operation of telegraph instruments and similar light service where but comparatively little energy is required.

Electric current used for ordinary light and power purposes is generated by what is known as a dynamo, or generator, the two terms being interchangeable when used in this connection. The dynamo depends for its action upon magnetism, and the fact that:

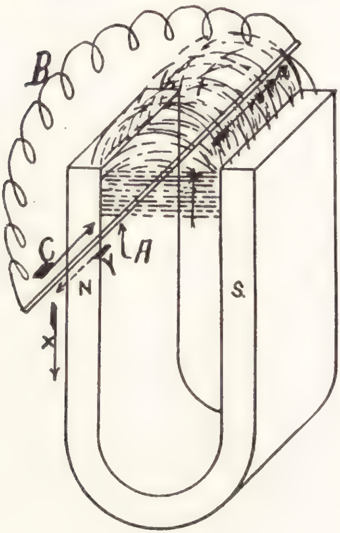

Figure 1.

When an electric conductor is moved in an electric field a current of electricity is generated therein which will flow in a direction at right angles to the line of motion.

In Fig. 1 we see this law illustrated, N and S being the north and south poles of an ordinary horseshoe magnet, the dotted lines representing magnetic "lines of force," which constantly flow between the poles of all electric magnets. The space occupied by these lines of force is termed a "magnetic field," and with a magnet of the type shown in Fig. 1 this field is, of course, strongest directly between the poles.

A represents an electric conductor, say an ordinary copper wire, with its ends joined by wire B, so that a continuous circuit is formed. If this wire be moved upward, in the direction of arrow A, an electric current will be generated therein, which will flow along the wire in the direction of arrow C, or at right angles to the line of motion. *If the wires were moved downward through the magnetic field in the direction of arrow X, instead of up, the current in the wire would flow in the opposite direction, as per dotted arrow Y, it, of course, being understood that the ends of the wire passing through the magnetic field must always be joined, so that a complete circuit is formed.*

No current would flow if the wire were merely a straight length, with its ends unjoined.

Now let us take a step in advance and examine Fig. 2. Remembering that if the electrical conductor in Fig. 1 be moved upward the current will flow to the right, and if it be moved downward it will flow to the left, transfer your gaze to Fig. 2, where you will see a loop of wire, X X, so arranged that it may be rotated on a spindle. One end of this loop connects to ring A, and the other end to ring B, and the ends are joined by means of brushes C and D and the wire E (outside circuit) attached thereto. Now if we revolve this wire loop (armature) in the direction indicated by small crank arrow, the side next us will move upward, while the other moves downward, so that on the side of the loop next us the current will flow to the right, toward collecting ring B, whereas on the other side it will flow to the left, away from the collecting ring A, but by reason of the fact that the wire is in the form of a loop the current flows clear around the coil, out through brush A, around wire E to brush B, and back into the loop again, and thus we have the electric action of a generator exemplified. This is how current is generated.

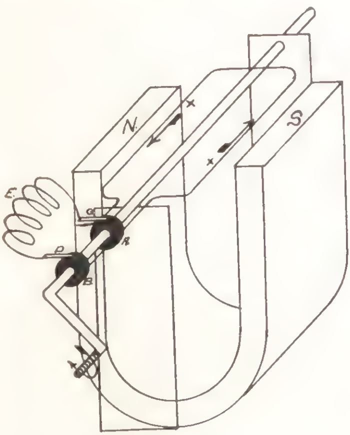

Figure 2.

NOTE.—Strictly speaking it is voltage (E.M.F.) which is generated, but my purpose is served by the use of the term "current," which is less confusing to the student.

But this is not all, since at the end of one-half revolution the two sides of the coils will have changed place, and the current, *still moving in the same direction with relation to the magnet,* will then be flowing away from ring A, and toward ring B, which, as you will readily see, means the reversal of the current within the wire coil itself, as well as in outside circuit B, and *this reversal must, perforce, occur with every half revolution of the coil, or armature.* In considering this matter, bear carefully in mind the fact that, with relation to the poles of the magnet, the current will always flow in the direction indicated by the

arrows; also remember that this wire coil merely represents one coil out of the many wound upon the armature of a generator, but that the electrical action in all armature coils is essentially the same as that of the one described.

I think after a careful study of the foregoing you will readily grasp the idea, and understand how current is generated in an armature coil; also why the current in the armature of a dynamo constantly reverses its direction, or, in other words, is "alternating."

The current in the armature of all generators reverses its direction as above set forth, though in multipolar dynamos (generators having more than two poles) it is reversed every time the coil passes from the influence of one set of poles into the influence of another set of poles, which may occur several times to each revolution of the armature.

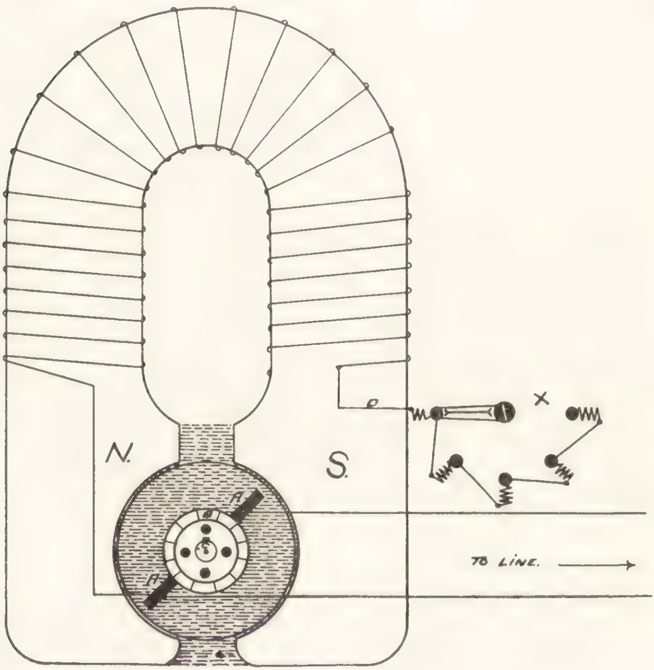

Figure 3.

All this is just as true of direct current generators as it is of alternating current generators, but in the case of the direct current dynamo the alternating current generated in the armature itself is rectified by what is known as the "commutator," so that the current on the *outside circuit* flows constantly in one direction, or, in other words, is direct current. As a matter of fact all electric dynamos generate alternating current in their armatures. A study of what has gone before will show that this could not possibly be otherwise.

Fig. 3 is an illustration of a simple form of dynamo, technically known as a "two-pole, shunt-wound" machine. N is the north and S is the south pole of its "field magnet." The dotted lines between its pole pieces represent lines of magnetic force, and its voltage and capacity will depend upon (a) the number of lines of magnetic force passing between the two poles, or, in other words, the "strength of the magnetic field," or, in other words, the "density of the magnetic flux" per square inch of the surface of the pole pieces on the side next to the armature; (b) the number of coils of wire the armature contains, and, (c) the rotary speed of the armature. Of course, there are other details of construction, such as the kind of iron in the magnets, size of magnets, kind of armature core, etc., which are of great importance, but these items only have to do with the efficiency of the machine, not its operating principle.

The magnet of this type of machine is what is termed a "permanent magnet." That is to say, the iron of its magnets remains magnetized after the armature has come to rest. The slight magnetism retained by the iron after the armature has stopped is termed "residual magnetism," and it is this residual magnetism which enables the machine to start up without having its magnets excited from an outside source. The residual magnetism is, however, very weak, and, in practice, running at normal speed, the average dynamo would generate five or at the most ten volts when operating merely on the residual magnetism of its field magnet, which would be totally inadequate for commercial purposes.

Now the voltage generated by the armature will depend upon the number of lines of magnetic force which the conductors upon that armature cut per second. The number of lines of force cut per second, and in consequence the voltage could, of course, be increased by increasing the number of coils on the armature, but in practice this would require an armature of huge proportions. The same effect could be had by increasing the speed of the armature, but there, too, is a

limit, and high speeds are objectionable. It therefore follows that the really practical method of increasing the number of lines of force cut per second is to establish the speed of the armature and the number of coils thereon, and then increase the density of the magnetic field until the desired result is attained, and this is the method which is adopted. It is done as follows: Examining Fig. 3 you will observe there is a wire coil around the top part of the poles of the field magnet. This wire connects with one brush, passes thence to one end of coils of resistance wire, known as the "field rheostat," and from the other end of these coils to and several times around one of the poles of the field magnet, across the air gap to and several times around the other pole of the field magnet, and thence to the opposite brush. This circuit is known as the "field circuit" or "shunt field circuit."

Now, it is a well known fact if a wire be wound around the poles of a magnet and an electric current be passed through the coil thus formed, the strength of the magnet will be increased; in other words, the magnetic field between its poles will be made more dense and powerful, or, in other words, the lines of magnetic force or the magnetic flux will be made greater; and this will continue as the current is increased until the point of saturation (iron is said to be "saturated" with magnetism when it will receive no more) is reached.

As applied to the dynamo, the operation of the field circuit is as follows: In starting up, the armature is revolved and brought up to speed by an engine or some other source of power. The armature coils cutting through the weak field created by the residual magnetism generate a slight voltage, and, the resistance of the field rheostat (See Fig. 3) having first been eliminated by means provided, a current is set up in the field coils, which, in compliance with the facts before set forth, instantly increases the strength of the magnetic field, and thus the armature coils are made to cut a greater number of lines of magnetic force per second and the voltage is increased, and so on until the voltage at which the machine is intended to operate has been reached, whereupon the handle of the field rheostat is moved, and resistance is cut into the field circuit in such amount as will just regulate the flow of current in the field circuit to the value which will hold the strength of the magnet field at a point which will cause the armature to cut just enough lines of force per second to maintain the desired voltage.

It will, of course, be readily seen that as the load on the generator changes an alteration of the strength of the magnetic

field will be necessary, or, in other words, variations in load of the generator will require the altering of the amount of resistance in its field circuit, which in some dynamos is accomplished automatically, while in others it must be done by hand.

All the foregoing applies in practice to the shunt-wound dynamo, and also very largely to the compound wound dynamo, but, no matter what the type of generator may be, the principle set forth holds good.

The current for the field circuit is taken direct from the armature of the generator, but this comprises a very small fraction of the total output of the machine—considerably less than 10 per cent.

It is not designed to do more than give a comprehensive understanding of the method by which electricity is generated. There are many excellent works on dynamo action and construction, which may be consulted at the public library of your city and the student can go as far as he likes in such matters. In this work I can only find space for such practical things with relation to dynamos as may be expected to be of direct assistance to operators who are obliged to manage and care for generators or a motor generator set.

THE DIFFERENCE BETWEEN ALTERNATING AND DIRECT CURRENT

Direct current, commonly called "D. C.," acts continuously in one direction, presumably from positive to negative. The electrical impulse or, putting it another way, the flow of current is, theoretically, outward from the positive brush of the generator to the positive wire of the circuit, along that wire to and through the various lamps, motors, etc., to the negative, and back on the negative wire of the circuit to the negative brush of the generator. Direct current is very seldom of higher voltage than 500, since above that pressure it becomes exceedingly difficult to effectively insulate the commutator bars of the generator from each other. Another reason why we do not find D. C. at high voltage lies in the fact that after leaving the generator its pressure cannot be raised without the use of machines having moving parts, which is impractical by reason of the expense of installation and operation, as well as the necessary loss inherent in such a device.

Alternating current is commonly known by the abbreviation "A. C." As has already been set forth, the current in the armature of all generators is alternating; that is to say, the

current in the armature coils constantly reverses its direction, and "alternating current" (A. C.) is nothing more or less than the unrectified current which is sent out on the circuit just as it is generated in the armature coils of the dynamo, so that the current in the whole circuit reverses its direction as often as the current is reversed in the armature coils of the dynamo.

There are several reasons why A. C. is very largely used, the main one being the fact that it may be generated at relatively high pressure; also the pressure (voltage) may be readily increased or reduced after the current has left the dynamo and this may be accomplished by means of a very simple device known as a "transformer," which has no moving parts, requires practically no care or attention, lasts indefinitely if not overloaded, and accomplishes its work of increasing or decreasing the voltage with comparatively little loss of energy.

The advantage of high voltage lies in the fact that while a wire of given size is rated at a certain, definite number of amperes and no more (See Table 1, Page 42), it will carry those amperes at any voltage. Electric energy, by which is meant the ability of the current to perform work, is measured in "watts." One watt is equal to 1/746 of a horse power. It therefore follows that 746 watts is equal to 1 horse power. Watts are found by multiplying volts by amperes, thus: 5 amperes at 110 volts equals (5×110) watts. Horse power equals volts multiplied by amperes divided by 746.

Referring to Table 1, Page 42, we find that a No. 6 rubber covered wire must not be allowed to carry more than 50 amperes of current. Now suppose we have a No. 6 wire carrying 50 amperes at 110 volts: $110 \times 50 = 5500$ watts, which divided by 746 (watts in a horse power) gives us approximately 7½ h.p. as the limit of power which can be conveyed on a No. 6 r.c. wire charged at 110 volts pressure. On the other hand, suppose we have the same No. 6 r.c. wire carrying 50 amperes at 2000 volts pressure. We then have $2000 \times 50 = 100{,}000$ watts, which divided by 746 equals almost 135 h.p., now being conveyed over a No. 6 r.c. wire which was loaded to capacity with 7½ h.p. when the pressure was 110 volts.

From the foregoing it will readily be seen that there is enormous saving in copper (wire diameters) effected by using high voltage. This is a particularly important item if the power (current) is to be conveyed any considerable distance. To convey 1000 h.p. five miles by means of 110 volts pressure would entail an enormous outlay for wires of large size, since

it would require nearly 7000 amperes, whereas with the current at 10,000 volts only about 75 amperes would be necessary.

As has been said, A. C., unlike D. C., does not flow continuously in one direction, but, quite the contrary, flows in one direction and then reverses and flows in the opposite. In other words, the current flows one way for a small fraction of a second and then reverses itself and flows in the opposite direction for an equal space of time, the period of flow in either direction varying from 1/50 to 1/266 of a second, according to the way the generator is designed. Two periods of flow—that is to say, the period during which the current flows in one direction and reverses itself and flows back—are called a "cycle." See definition of cycle, page 22.

Alternating current dynamos may be designed to produce current of any given number of cycles per second, the determining factor being the use the current is to be put to. Where light only is produced, the current frequency (number of cycles per second) may be quite high; sometimes as much as 133 cycles (266 alternations) per second; but of late years the use of current frequency in excess of 60 has been almost entirely abandoned.

Where the current generated is to be used entirely for power purposes a low frequency is much preferred, for the reason that it is more economical for driving motors. Power current runs as low as 25 cycles per second, which is the ideal current to apply to motors. Twenty-five cycles per second, however, is unsatisfactory for incandescent or arc lighting, since the alternations are so far apart that there is a noticeable flicker in the light. Light and power companies long ago discovered the fact that 60-cycle current produces very satisfactory results in lighting, and is at the same time fairly economical for power purposes. For this reason practically all generators designed to provide both light and power are what is known as 60-cycle machines.

It is essential that the operator get a clear understanding of these things, since more and more they are called upon to handle motors and generators, and moreover in some localities and under some conditions problems arise which can only be solved by one conversant with this subject. The action of alternating current is usually expressed by diagram, such as that shown in Fig. 4, and I will now try to help you to understand how to trace out the real meaning of such diagrams. Indeed, it is very necessary that you do understand, because when one studies matters electrical, he is constantly

confronted with diagrams of this character, and if unable to trace out their meaning is greatly handicapped in his study.

Let us consider Fig. 4. In its length the horizontal line represents time, and in its position with relation to the triangles above and below it represents zero voltage, or, in other words, no voltage, or, in other words, it represents the point at which the alternations of the current are completed and the voltage and amperage are both at zero.

From 0 to 1 represents the time of one alternation, which with 60-cycle current would be 1/120 of a second; the rise and fall of voltage in that alternation being represented by the

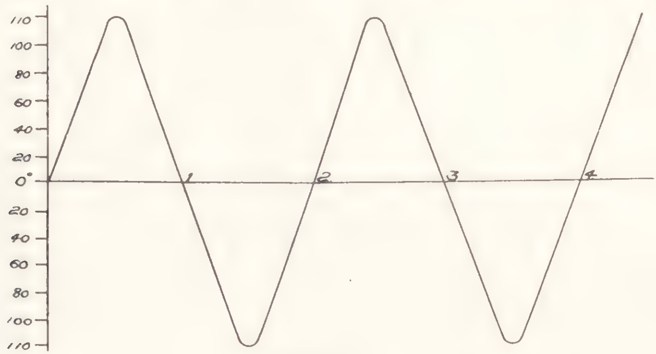

Figure 4.

triangular line above the horizontal line which leaves 0, mounts upward and comes back down to 1. The vertical column of figures represents voltage. Turn back to Fig. 2 and examine it and the text matter dealing therewith, so that the action of an armature coil will be fresh in your memory. Remember that when the coil in Fig. 2 is in the position shown, it is generating maximum voltage, and, conversely, when standing straight up and down it is in what we call the "neutral plane," and for an infinitesimal fraction of a second is generating nothing. Now, coming back to our diagram, Fig. 4, where the line of the triangle leaves and mounts upward, the coil of the armature is beginning to cut lines of force in increasing number, and the voltage is rising and continues to do so until the coil is cutting the maximum lines of force, at which time the voltage has reached 110. Meanwhile time equal to half of an alternation, or, $1/120 \div 2 = 1/240$ of a second, has elapsed. Now the armature coil begins to pass

out of the magnetic field, and the voltage decreases until, following the right-hand line of the triangle down to 1, it is at zero, and the current reverses. If we now follow the line on down on the left-hand side of the lower triangle and back up to 2, we will have traced the action of two alternations, or one cycle of current, and during that time 1/60 of a second will have elapsed. Now, in your imagination, draw a pencil point from 0 to 1, and another pencil point round the upper triangle, and then continue the first pencil out on to 2 and run the other pencil point down around the lower triangle. If you could draw one pencil point from 0 to 2 in 1/60 of a second, and in the same length of time trace the two triangles, one above and one below the line, to 2, with the other pencil point, you would have exactly typified the action of one cycle of alternating current, both as to time and rise and fall of voltage and amperage.

With 25-cycle current, the action would be precisely the same, except that from 0 to 2 would represent 1/25 of a second, instead of 1/60 of a second, and the action of the current therefore would be just that much slower.

In studying the above get the fact clearly fixed in your mind that, while the action is almost inconceivably rapid, still it is a fact that *with plain, single-phase alternating current, twice during each cycle, or one hundred and twenty times every second, there is absolutely no voltage, amperage, or anything else on the line.* This is hard for the mind to grasp, since it is very difficult for the mind to accustom itself to such extreme rapidity of motion.

The student may ask: "Well, if it is a fact that there is no voltage or amperage on the line twice during each cycle, how does it happen that the light from alternating current is continuous?" In reply I would say that the light is *not* continuous, but the action is so enormously rapid that the effect of one alternation blends in the next, so that with 60-cycle current the effect is that of continuous, uninterrupted, even illumination, but if the current be 25-cycle, then the action is slow enough that the eye can detect an uneveness of illumination, in the form of flicker, and that is why very low cycle alternating current, while ideal for power purposes, is objectionable and unsatisfactory for lighting.

In handling alternating current we run into many complications, one of which is the fact that we have single-phase, two-phase, and three-phase current to deal with. In Fig. 4 we have traced the action of alternating current. In Fig. 5 we see, at A, a diagrammatic representation of two-phase

current. Two-phase and three-phase current is produced by a peculiarity of the winding of the generator. However, for the purpose of a clear understanding, we will assume that we have two generators, producing current of the same cycle, with their armatures coupled rigidly together in such manner that when the current flow of one is at zero the voltage of the other is at maximum. We will thus have a two-phase current delivered, and the voltage of such a circuit will never be at zero, since when the current generated by one of the machines is at zero the other is at maximum. Now, if we couple the shaft of a third dynamo to the shafts of the other

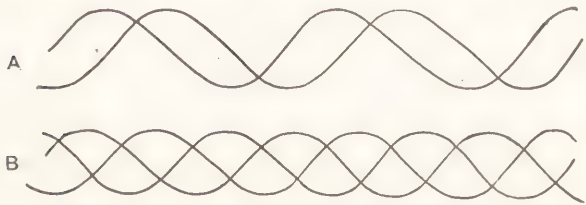

Figure 5.

two, in such manner that the voltage rises and falls, as shown at B, Fig. 5, we shall have three-phase current. Two-phase current ordinarily employs four wires (two separate circuits) for its distribution. Its advantage lies in the fact that the two currents, acting like the piston of a double engine, give a steady instead of an intermittent pull on the armature of motors. Three-phase current requires three wires for its distribution. It is the ideal system for transmitting energy, through any distance, for power purposes. It gives a practically steady pull on the motor armature. Neither the two nor three phase systems has any particular advantage over single-phase 60 cycle current for lighting purposes.

Electrical Terms

IT is essential that the operator have a complete understanding of certain terms used in connection with electrical work. It is quite difficult to impart a clear understanding of some of the terms, but we will nevertheless do our best to make the matter at least reasonably clear.

Work is the term used to describe the act of overcoming resistance through a certain distance. It is measured in foot-pounds. See foot-pounds.

Foot-pounds.—A foot-pound is the amount of work done or energy consumed in raising a weight of one pound one foot, or the equivalent, such as, for instance, raising one-half pound two feet, or raising two pounds one-half foot. It may also be described as overcoming a pressure of one pound through a distance of one foot.

Coulomb.—The coulomb is used to measure the quantity of current flowing in one second. It is the number of amperes of current passing in one second. It is the product of the amperes times seconds, thus:

> 10 amperes flowing in 1 second multiplied by 1 second equals 10 coulombs; 10 amperes flowing for 2 seconds equals 20 coulombs.

Volt-Coulomb.—The volt-coulomb is the electrical unit of work. It is that amount of work performed when one ampere of current flows for a period of one second in a circuit whose resistance is one ohm, when the pressure is one volt.

Ampere-Hour.—One may draw a certain quantity of water, say a gallon, from a hydrant in one minute, or in ten minutes, but, regardless of the time consumed in drawing the water, it is still one gallon, no more and no less. The same holds true in dealing with electric current. A certain given quantity may be used in one minute, or in ten minutes. The current flowing in any circuit is the relation of the quantity flowing to the time during which it flows, or, expressed otherwise:

As has been said, coulombs equals amperes multiplied by seconds, or,

2 amperes $\times$ 10 seconds $=$ 20 coulombs.
10 amperes $\times$ 2 seconds $=$ 20 coulombs.
1 ampere $\times$ 20 seconds $=$ 20 coulombs, and so on.

By the foregoing you will be able to calculate that if one ampere flows for one hour we would have 1 ampere $\times$ 60 seconds $=$ 60 coulombs, and 60 coulombs $\times$ 60 minutes $=$ 3600 coulombs, so that one ampere flowing for one hour equals 3600 coulombs, and 3600 coulombs are, therefore, one ampere-hour, or a flow of 2 amperes for one-half hour would be one ampere-hour, or a flow of 4 amperes for 15 minutes would be one ampere-hour, since in either case 3600 coulombs would have been used.

Ampere.—Ampere is the unit rate of current flow. It represents the quantity of current flowing through a circuit, precisely the same as gallons or barrels represent the quantity or volume of water flowing through a water pipe.

Operators should carefully consider the distinction between the ampere and the coulomb. The term coulomb is not much used, but it is nevertheless one of much importance, since it measures the quantity of current passing *in a given time.*

The ampere is such a rate of flow as would transmit one coulomb per second through a resistance of one ohm, under a pressure of one volt; a current of such strength as would deposit .005084 grain of copper per second.

Volt.—The volt is the unit of electric pressure. It is the electro-motive force induced in a conductor, usually an armature coil, which is cutting 100,000,000 lines of magnetic force per second. It is the term used to designate the strength of the affinity of one wire of an electric circuit to and for the other wire. It is the term used to designate and describe the intensity of electrical action. It is the term used to designate that quality or property of the electric current, or electric action, which corresponds to pressure in a steam boiler, or in a water pipe.

Ohm.—Ohm is the unit of resistance. It is the term used to designate and measure the opposition offered to the flow of electric current. It is the amount of resistance offered by a column of mercury 106 centimeters in length, having an area of cross section of one square millimeter, at 0 degrees centigrade, or 32 degrees F. This is the established international value of the ohm, designated as the "Legal Ohm."

Watt.—Watt is the unit of power. It is obtained by multiplying volts by amperes: 1 volt $\times$ 1 apmere $=$ 1 watt, hence, 10 amperes at 110 volts would be, $100 \times 10 = 1100$ watts; 746 watts equal 1 horse power (h.p.). See kilowatt. See watt-hour.

Kilowatt.—Kilowatt is merely a term of convenience, meaning 1000 watts. It is $1000 \div 746 = 1.34$ horse power.

Watt-Hour.—One watt-hour represents the amount of work performed by one ampere of current at one volt pressure during a period of one hour, hence, 4 amperes at 110 volts would be 440 watts, and when that amount of energy has been expended for a period of one hour it would be 440 watt-hours.

Horse-Power.—One horse-power (h.p.) equals 33,000 foot-pounds of work per minute. It is the theoretical amount of work one strong draft horse is supposed to perform if a block and tackle be attached to a weight of 33,000 pounds and the tackle be of such proportion that the horse can, by exerting his full strength, just raise the 33,000 pounds one foot while walking outward pulling on the rope for a period of one minute. Under these conditions one horse-power has been ex-

erted during that minute. That is the theory of the thing. One horse-power-hour is the amount of work exerted by one horse during one hour, or by 60 horses during one minute, or by 3600 horses during one second. In electrics 746 watts is supposed to represent the raising of 33,000 pounds one foot in one minute, or, in other words, one horse power. The unit was established as follows: 1 watt is equivalent to 1 joule per second (the joule is the practical C.G.S. unit of electrical energy. One joule is equal to .73734 of a foot-pound, or, .00134 h.p.-seconds; it is the quantity of electric energy necessary to raise the potential of one coulomb of electricity one volt in pressure) or 60 joules per minute, and 1 joule is equal to .73734 of a foot-pound, therefore 60 joules $= 60 \times .73734 =$ 44.24 foot-pounds. Now, since one horse-power equals 33,000 foot-pounds per minute the electrical equivalent would be $33{,}000 \div 44.24 = 746$ watts.

Resistance is that property of an electrical conductor by which it resists the flow of electric current. It is quite similar in its effect on electric current to the opposition water encounters in flowing through a pipe by reason of friction with the walls of the pipe.

Polarity.—Polarity is the difference in condition between the positive and the negative electrodes of a battery, or of two wires attached to the positive and the negative electrodes of a battery. It is the difference in condition between the two terminals of a working dynamo, or between the wires attached thereto. It may be described as representing the ability of the two battery electrodes, dynamo terminals, or wires attached thereto, to perform work. Positive: from which electric impulse comes or "flows." Negative: opposite of positive.

Short Circuit.—The term applied to a direct, accidental current-carrying connection between two wires of opposite polarity, by means of which the current is enabled to skip a portion of its appointed path.

Shunt Circuit.—A subsidiary or secondary circuit on any part of a main circuit, by means of which a portion of the current leaves the main circuit and flows through the subsidiary or secondary circuit, as, for instance, the field magnet circuit in Fig. 3, page 10.

Commutator.—A device attached to the armature of a dynamo by means of which the alternating current generated in the armature coils is changed into direct current for delivery to the outside circuit.

Direct Current.—Current which flows continually in one direction.

Alternating Current.—Current which flows alternately in one direction and then in the opposite, the time of the flow in either direction varying from 1/50 of a second to 1/226 of a second, according to the construction of the generator.

Conductor.—A wire or metal bar used to convey electric current.

Cycle.—Events following each other in regular succession. One-half the number of changes in direction of alternating current per second. Two complete alternations of alternating current.

Dimmer.—An adjustable choke or resistance coil used for increasing or decreasing the resistance in an incandescent circuit gradually, so that the incandescent lamps attached thereto will be extinguished or lighted gradually. An adjustable rheostat for use on incandescent light circuits.

Electric Motive Force.—Another name for voltage, and the one commonly employed in text books.

Ground.—A connection between wires of opposite polarity through the ground, having resistance low enough to allow current to pass from one wire to the other.

Static Electricity.—A form of electricity which is generated by friction.

Main Feeder.—The street circuit entering a district to which feed wires supplying the various streets are attached.

Street Mains.—Feed wires supplying individual house mains.

Electro Magnetic Field.—The field produced by an alternating electric current or by an electric magnet.

Magnetic Field.—That region of magnetic influence which surrounds the poles of a magnet or wire carrying A. C.

Fuse.—A short length of wire interposed in an electric current, the same being of some alloy which will melt (thus breaking the circuit and stopping the flow of current) at a temperature much less than that necessary to raise the temperature of a copper circuit wire to the danger point. Fuses usually melt at less than 300 degrees F.

Galvanized Iron Wire.—An iron wire coated with zinc, in order to resist the action of corrosion.

Graphite.—A condition of carbon in which it becomes an excellent lubricant, able to withstand very high temperature.

In this condition it forms the "lead" of the ordinary lead pencil.

Induction.—The influence which a mass of iron charged with alternating current exercises upon surrounding metallic bodies, without having any actual metallic connection therewith.

Insulation.—The employment of any material having such high resistance that electric current is unable to pass through to the earth, or other current carrying substance, and thus reach a wire of opposite polarity. Rubber, porcelain and glass are examples of insulating materials.

Magnetic Saturation.—That point at which the power of a magnet cannot be further increased.

Torque.—That force which tends to produce a rotary movement around an axle, as the pulling or rotating of an electric motor's armature upon its shaft. The force applied to the rim of a dynamo pulley by a belt. Turning force.

Transformer.—An induction coil by means of which the voltage of a circuit may be changed without materially altering its wattage. A step-up transformer is one which transforms a current of given amperage and voltage to a current of less amperage and higher voltage. A step-down transformer is one which transforms a current of given amperage and voltage to a current of less voltage and higher amperage.

Ampere Turn.—A unit of magneto-motive force equal to the force resulting from the effect of one ampere passing around a single turn of a coil of wire.

Voltmeter.—An instrument by means of which the voltage or electro-motive force of a circuit is measured.

Ammeter.—An instrument by means of which the current flow in a circuit is measured in amperes.

Wattmeter.—An instrument by means of which the power being consumed in a circuit is measured in watts.

Current Frequency.—The number of cycles per second.

Efficiency.—The term used in describing the loss inherent in transformers, motors, generators, generator sets, etc. Electrically it is the relation of the wattage taken from the line to the wattage actually employed in the work in hand. For instance: If a motor takes 3000 watts from the line and only exerts a pull on the thing it is driving equal to 2000 watts, then its efficiency would be the percentage found by dividing 2000 by 3000, and $2000 \div 3000 = .666$ or 66 2/3 per cent.

Circuit.—The term commonly applied to wires of opposite polarity to which are attached other power consuming circuits or lamps, motors, etc.

Synchronism.—Synchronism is the term used to describe the action of A. C. alternations with relation to each other. Synchronism is sometimes referred to by electricians as "keeping step." It means that where two or more alternating currents are coupled together, as in two or three phase current, their voltage values must rise and fall constantly with fixed relation to each other, as shown in Fig. 4, Page 16. In order to produce two or three phase current the voltage values must remain absolutely in step or synchronism with each other. When a motor is run in synchronism with a generator it means that the voltage value of the alternations in the armature of the motor arc and must remain absolutely identical with the voltage value of the alternations in the armature of the generator. Once you grasp the real meaning of Fig. 5 the understanding of synchronism will be easy, therefore study Fig. 5.

An Explanation of Electrical Terms

I HAVE given you the definition of certain electrical terms which the operator is likely to come into contact with in his work. In order to convey a more complete understanding of the true meaning of certain ones of these terms, however, something more than a mere definition is necessary, therefore I shall elaborate by amplifying certain definitions in the form of an explanation.

Polarity.—Polarity and potential mean the same thing. When a wire is attached to one terminal of a working dynamo and another wire is attached to the opposite terminal of the same dynamo there is an electrical condition in these wires which enables them to perform work, or, more correctly, to cause a motor to which they are attached to perform work, or cause a lamp to which they are attached to give off light. This electrical condition is called "polarity," or "potential." It is the affinity one wire of an electric circuit has for the other wire of this circuit. It represents the inclination of the current to flow from one wire to the other wire, and this inclination is so strong that in order to pass from one wire to the other the current will perform labor, and lots of it. When dealing with direct current one wire is always positive and

the other is always negative; when dealing with alternating current each wire is alternately positive and negative many times each second.

Voltage (E.M.F.).—Electric current may be said to have both pressure and volume, and in its action in both these respects, as well as with regard to friction, electricity is very similar to and may be compared with water or steam. We must, however, carefully remember, when using these comparisons, that *they only hold good as applied to the laws of electrical action which have been determined by experiment.* In other words, the similarity between electricity and water or steam exists *only* in their similarity of action. Water may be perceived by the senses; we can feel it and watch its action, whereas electricity is an absolutely impalpable substance, which cannot be perceived by any sense except that of touch, and even then it cannot be felt except through the "shock" occasioned by its passing over the tissues of the body. (We can see electric light, yes, but that is only the effect of the current, not the current itself.)

Voltage corresponds in effect or in its action to the pressure of water in a pipe, or to the pressure of steam in a boiler. A dry battery, such as is used for electric bells, has a pressure of approximately one volt, and it imparts that pressure to wires connected to its terminals, so that if you attach two wires to such a battery they will, at any portion of their length, have a pressure of one volt. Now, if you take a second battery and connect its zinc with the carbon of the first battery by means of a short piece of wire, and then attach two other wires to the two remaining binding posts, you will have what is known as "series" connection, and a resultant pressure of two volts between the two wires. A third battery connected in series would raise the pressure to three volts, and so on, indefinitely. Instead of using batteries for producing light and power, which would be entirely impractical, we use a machine called a dynamo, each one of which is designed and built to produce a certain voltage, which may be anywhere from one to five hundred volts D. C., or from one to six thousand A. C.

Remember that voltage corresponds to pressure, and is similar in its action to pressure in a steam boiler, but that voltage acts only between the positive and negative wires of the dynamo which generated it, and that the positive attached to one generator has no affinity or attraction to or for the negative attached to another dynamo, or for the ground, except as it offers a path to the negative of the generator to

which the positive is attached. Get this fact firmly fixed in your mind. Ninety-nine non-electricians out of every hundred believe current generated by a dynamo seeks to escape into the ground. This is not so, except as the ground offers a path between two wires of opposite polarity. If the positive or negative side of a dynamo generating 5000 volts be thoroughly and completely insulated (never actually the fact in practical work) you could stand on wet ground and handle the bare wire of the other side with your bare hands in perfect safety.

Ampere.—Ampere is the term used to denote quantity. It represents the volume of current flowing through, or along a wire, just as gallons or barrels represent the quantity of water flowing through a pipe, or cubic inches the volume of steam flowing. As a matter of fact we do not actually know that anything flows in or along the wire of an electric circuit. Eminent electricians say there is an actual flow; other equally eminent electricians say there is not, but that what we consider as current flow is really a "molecular bombardment." With these highly technical questions, however, we have nothing to do. *For our purpose it is sufficient to say that current flows along the wire, just exactly as water flows in a pipe.* The work performed is accomplished by the voltage or pressure working through the amperage or volume, and it is the pressure or voltage which is consumed—never the amperes. Therefore, the higher the voltage or pressure, the greater amount of work a given volume of current can perform. For instance: If you supply a steam engine with steam at fifty pounds' pressure it will consume a certain given quantity or volume of steam to each stroke of the piston, according to the cubic capacity of the cylinder, and this quantity of steam at fifty pounds pressure will do a certain given amount of work.

Now, if you raise the pressure of the steam to one hundred pounds the engine will perform twice as much work, but will not consume any greater number of cubic inches of steam. And so it is with electric current: One-half of an ampere at 50 volts will do a certain amount of work, but the same one-half ampere at 100 volts will do just twice as much. In other words, the amperage or volume of current is simply the medium through which the voltage or pressure (E.M.F.) acts, or works. In a steam engine, with the steam at given pressure, you can increase the power of the engine by either increasing the size of the engine cylinder, or by increasing the pressure of the steam. In a water motor you can increase the capacity to do work either by increasing the size of the motor or the pressure of the water. The same thing holds

true with electricity. You can increase its capacity to do work either by increasing the volume of current (amperage) or by increasing the voltage. To perform a given amount of work with a low pressure (voltage) a large volume (amperage) is necessary, but if the voltage be high the same amount of work can be performed with much less volume of current. In fact, the number of horse power of work performed by electric current is represented by the voltage times the amperes, divided by 746.

Ohm.—Water in passing through a pipe encounters resistance, by reason of the rough sides of the pipe, as well as by reason of the internal resistance of the water itself. This resistance tends to retard the flow. Precisely the same is true with electricity. In passing through a wire electric current encounters resistance, and this resistance tends to retard the flow of current. It is measured in ohms, the definition of which is given elsewhere. The effect of resistance is to produce heat. In a water pipe the resistance increases as the volume of water passing through the pipe is increased, or as the pipe is made smaller in relation to the volume of water flowing. It decreases as the pipe is made larger with reference to the volume of water flowing. The same thing is true of current. Having a wire of given area, the resistance increases as the current flow becomes greater, and decreased as the current flow becomes less, or, having a given current flow the resistance increases as the diameter of the wire is made less or its length is increased, or decreases as the diameter of the wire is made greater or its length is decreased.

Watt.—Watt is the unit used to measure the amount of electrical energy expended—the amount of work actually performed. It is found by multiplying the voltage by the amperage, and is transformed into horse power by dividing by 746, since 746 watts equal one horse-power.

For example: If we have 10 amperes flowing at 110 volts, the amount of energy expended would be equal to $110 \times 10 = 1100$ watts, which, divided by $746 = 1.47$ h. p. If, on the other hand, we had 110 amperes flowing at 10 volts the result would be the same. But if we had 10 amperes flowing at 10,000 volts then we would have electrical energy expended (work performed) as follows: $10{,}000 \times 10 = 100{,}000$ watts $\div 746 = 134$ h. p.

Use of Electrical Terms in Calculation

IT is quite problematical as to how much use the average operator will be able to make of electrical terms in making calculations, since, in order to find an unknown quantity he must know two other quantities. In order to calculate the number of amperes flowing in a circuit it is necessary the voltage and resistance in ohms be accurately known, and, while the operator usually knows about what the voltage is, the resistance is seldom a known quantity, or one which the operator can readily ascertain with any degree of accuracy. To find the number of ohms resistance, the operator must know the exact amperage and voltage, which he can, if necessary, obtain by means of a reliable voltmeter and ammeter. To find the voltage he must know the exact resistance in ohms and the exact amperage. But, notwithstanding the fact that only two of these quantities are usually known to the operator, and those two often only known approximately, the operator ought to understand how to make electrical calculations, particularly with relation to his projection arc circuit, and I shall therefore give a somewhat extended explanation of the method.

The operator must fix firmly in his mind the fact that where the projection lamp circuit is concerned the resistance does not lie wholly in the rheostat, or whatever takes its place. The wires, lamp arms and carbons offer small resistance, but a very considerable portion of the total is in the arc itself. The resistance of the wires, lamp arms and carbons may, for ordinary purposes, be neglected, but unless the resistance of the arc itself be taken into consideration a very serious error will result.

When making electrical calculations it is customary, for the sake of brevity, to use the letters E, C and R. E stands for "electro-motive force," which is merely another name for voltage, hence E stands for voltage; C stands for current flow, meaning amperes, hence C stands for amperes; R stands for resistance in ohms, hence R stands for ohms.

The operator should also remember that in a common fraction the horizontal line always means "divided by," thus ½ really means $1 \div 2$. But I think I hear some one say you cannot divide one by two. Oh, yes, you can. It is done thusly: We put down the one, followed by a period, called a "decimal point," and then add ciphers, thus: 1.00. We now have 1.00 with a decimal point between the one and the two 00s, and $1.00 \div 2 = .50$, or, .5, which is exactly the same thing

as 50/100, 5/10, or 1/2. The rule is to count the figures or ciphers to the right of the decimal point in the number being divided, and then, beginning at the last figure of the result, count an equal number, and place the decimal to the left of the last figure counted. If there are not enough figures in the result to do this, then add ciphers to the left.

When dealing with formulas, $\frac{E}{C}$ means that the quantity represented by E is to be divided by the quantity represented by C, E being the voltage and C amperes. If there be two or more quantities above or below the line, with no sign between them, it means they are to be multiplied together, thus: $\frac{E}{C\ R}$ means that E (volts) is to be divided by C (amperes) multiplied by R (ohms), $\frac{E - 15}{C}$ means that after 15 has been subtracted from the quantity represented by E (volts) it is to be divided by the quantity represented by C (amperes). The student will be greatly benefited if he will practice writing out formulas of this kind in letters, substituting quantities in figures and working them out.

Ohms law sets forth the fact that the number of amperes flowing are equal to the voltage divided by the resistance in ohms. We, therefore have $\frac{E}{R} = C$, or, in other words, volts divided by ohms equals amperes. It then follows that if $\frac{E}{R} = C$, C multiplied by R must equal E. It also follows that $\frac{E}{C} = R$. It works out as follows: We know that the ordinary 110-volt 16 c.p. carbon filament incandescent lamp requires approximately one-half ampere of current to bring it up to candle power. What is its resistance? Using the formula $\frac{E}{C} = R$, substituting figures, we have $\frac{110 \text{ volts}}{.5 \text{ of an ampere}} = 220$, the number of ohms resistance in the filament of the lamp.

Again applying the formula $\frac{E}{R} = C$, we have $\frac{110}{220} = .5$, or ½, as the amperage 110 volts will force through 220 ohms resistance. It seems to me all this is simple enough of understanding and application, but to make it yet more plain I will take the formula $\frac{E}{C} = R$, which means voltage divided by amperes equal ohms, so that if the voltage be 50 and the amperes 10, E would mean 50, C 10, and R would be $50 \div 10 = 5$, but if the voltage be 110 and the amperage 5, then E would mean 110, C 5 and R would be $110 \div 5 = 22$ ohms.

When, however, we come to consider the projection arc circuit, a new element enters in the shape of the resistance of the arc itself, and if we propose to be absolutely accurate we must consider also the resistance of the carbon arms, wires, etc., but that degree of refinement is seldom or never necessary in a projection circuit calculation.

In leaping the air gap between the carbon tips of the arc lamp the current encounters high resistance. In overcoming resistance voltage is consumed, as will be more thoroughly set forth and explained under "Resistance," Page 34. In other words, when current-flow is opposed by resistance, and that resistance is overcome, there is a consequent drop in pressure or voltage; pressure has been used, or consumed in the process. The resistance of the arc, consequently, the voltage drop in overcoming the resistance, is proportional to (a) length of arc; (b) size and characters of the carbons; (c) kind of core in the carbon; (d) number of amperes flowing. All these factors enter very decidedly into the equation, but very largely the resistance encountered is directly proportional to the length of the arc.

For reasons not necessary to enter into at this time the D. C. arc, for a given amperage, is longer than the A. C. arc. It, therefore, follows that its resistance will be higher. The accepted theory is that all voltage is consumed at the arc. Whether or not this is true is a highly technical question, which it would be unprofitable to discuss in these pages. We shall accept the theory. Therefore the rheostat or whatever takes its place must cut down the voltage to just that pressure which the resistance of the arc will consume when burning normally.

When an ordinary D. C. projection arc is operating at its best it consumes about 48 volts. The D. C. arc voltage varies

from 45 to 55, but 48 is a fair average. In other words, the current must reach the arc at that pressure, and that pressure will be consumed in the arc. Ordinarily it is spoken of as "48 volts drop across the arc." What is the resistance of such an arc operating at 40 amperes? Knowing the voltage (48), and amperage, we apply the formula $\frac{E}{C} = R$, and have $48 \div 40 = 1\,1/5$ ohms arc resistance. Let us prove this out. Suppose the line voltage to be 110. The total resistance must equal ($\frac{E}{C} = R$) the voltage divided by the amperes flowing; therefore, the amperage being 40, the resistance must be $110 \div 40$, or $2\,3/4$ ohms. We have seen that the arc resistance is $1\,1/5$ ohms with its voltage at 48. Subtracting the arc voltage from the line voltage leaves us 62, as the drop in voltage there must be across the rheostat. Again applying the formula ($\frac{E}{C} = R$), we have $62 \div 40 = 1\,11/20$ as the ohmic resistance of the rheostat. Adding this and the arc resistance together, we have a total of $(1\,1/5 + 1\,11/20)\ 2\,3/4$, as the total resistance, which corresponds to the total resistance necessary to allow 40 amperes to pass through.

If the amperage were 45, then the total resistance, voltage remaining the same, must be less. If the amperage were less, then the resistance would necessarily be greater. The higher the voltage the greater must be the resistance, as will be seen by applying the formula $\frac{E}{C} = R$, to accomplish a given current flow. Resistance is always found by application of the formula last quoted.

Arc resistance, as we have said, will vary somewhat, according to the character of carbons and cores, the amount of current flowing and the arc length, particularly the latter. However, with the D. C. projection arc we are reasonably safe in taking the constant 48, for the arc drop, or arc voltage, unless the amperage is low—say 30, or less, when 45 will serve better. Such a standard is necessary, even though more or less inaccurate, since the operator seldom has a voltmeter with which to measure the arc voltage exactly. Instead of applying

the formula $\frac{E}{C} = R$, as it stands, we first subtract the arc voltage (using the standard 48), from E, which represents the line voltage, thus securing, at one operation, the total resistance other than that of the arc. The problem then reads, for any D. C. arc above 30 amperes, $\frac{E-48}{C} = R$, but the "R" in this case is the necessary ohmic resistance except that peculiar to the arc itself. In subtracting 48 we have accounted for the arc resistance. For an arc of 30 amperes, or less, the formula is $\frac{E-45}{C} = R$. For the ordinary A. C. projection arc, up to 60 amperes, the formula to be used is $\frac{E-35}{C} = R$. In other words we use 35 as the A. C. constant for arc voltage, instead of the 48 used for D. C.

Suppose we wish to construct, or order a rheostat to deliver 25 amperes on 125 volts line pressure, when working in series with a D. C. projection arc. We use the formula $\frac{E-45}{C} = R$. Substituting figures for letters we have $\frac{125-45}{25}$, which equals the necessary ohmic resistance of the rheostat, not taking account of line and carbon resistance. $125 - 45 = 80$ and $80 \div 25 = 3\ 1/5$, the number of ohms resistance the rheostat must contain. If it were a 40 ampere arc we would subtract 48 instead of 45. If it were an A. C. arc we would subtract 35.

Were we to connect the same rheostat between the wires of a circuit carrying the same voltage without an arc in series, or, what amounts to practically almost the same thing, freeze the carbons of the arc lamp, we would then find the 3 1/5 ohm rheostat, which delivered 25 amperes in series with an arc, to be delivering $(\frac{E}{R} = C)$ $110 \div 3.2 = 34.4$ amperes, almost.

RULE OF THUMB

There is a very simple formula, easy of application, which combines the three formulas into one. It is called the "Rule

of Thumb." It is expressed for general use as: $\frac{E}{CR}$.

To use the formula you have but to cover the symbol or letter representing the quantity desired, and what remains will produce the answer, thus: Suppose we wish to ascertain the resistance in ohms. We cover up the "R" in the formula and find that we have $\frac{E}{C}$ remaining, which will give R, the desired quantity. In using this formula on projection circuits the top letter must be expressed as E minus the arc voltage, the same as in the regular formulas, thus:

$$\frac{E-48}{CR} \text{ or } \frac{E-45}{CR} \text{ for D. C. and } \frac{E-35}{CR} \text{ for A. C.}$$

Go to your work each day as though it were your first day on a new job and you had to make good.

Resistance

ONE of the most difficult problems confronting the operator and the electrician is resistance. This is a factor which is met with in almost every phase of electrical work, and, so far as light be concerned, it may be said to be the very foundation stone of the structure.

How Resistance Acts.—In passing through a wire, current encounters resistance, which is, in its action, very similar to that encountered by water under pressure in passing through a pipe. When water flows through a pipe it encounters resistance directly in proportion to the size and length of the pipe and the quantity of water flowing per minute. This resistance is to some extent the result of molecular friction within the water itself, but mostly it is caused by friction between the water and the sides of the pipe. In a pipe of given diameter, resistance increases with (a) increase of the flow, or volume of water, (b) increase of the length of the pipe, and (c) with the roughness of the inside of the pipe. Conversely it decreases with decrease of the flow, the shortening of the pipe or with increased smoothness of pipe walls. With a given flow of water, resistance increases with the length of the pipe, the decrease in its diameter or added roughness, and decreases as the pipe is made larger or shorter or smoother.

Resistance consumes pressure, and pressure is consumed exactly in proportion to the amount of resistance encountered. In the second edition of my Handbook I explained this proposition by means of a diagram, and I do not think that particular thing can be improved upon, therefore it is herewith reproduced in somewhat different form.

In the illustration we see a water main, with a pressure gauge registering 100 pounds, to which are connected three pipes A, B, and C. On A is a pressure gauge placed right up close to the main pipe and another near its outer end. We will assume the diameter of this pipe to be one-half inch. At B is a short pipe of the same diameter; at C is a pipe three inches in diameter for ten feet of its length, with a three-foot extension of half-inch pipe at its end. At the outer end of the large pipe is a pressure gauge, with another at the end

of the extension. Now let us consider the action. Pipe B is short and, being open at its end, the water spurts out with great force, carrying itself almost horizontal for a considerable distance, thus showing that the pressure at the mouth of the pipe is high. The water at the end of pipe A does not come out with such great force, and if we examine gauge No. 1 and gauge No. 2 we shall find that, whereas gauge No. 1 registers very nearly the same as the one on top of the main pipe, No. 2 will register far less. Gauges No. 1 and No. 2 are on the same pipe. What is the explanation of the difference in pressure?

The answer is simple. It has been used up in forcing the water at high speed against the friction of the pipe. The pipe is, under the conditions, working above its normal capac-

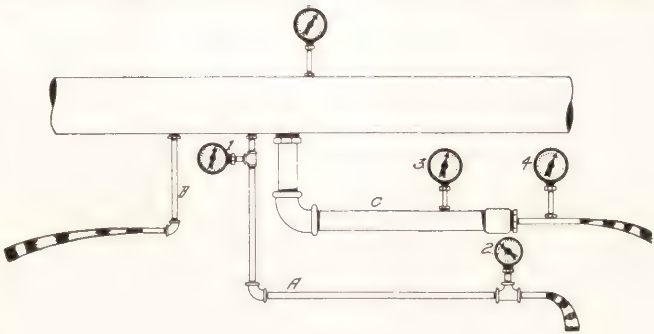

Figure 6.

ity, with the result that very high resistance is developed, and the greater the resistance the more power (pressure) is consumed in overcoming it.

Examining gauge No. 3 at the end of the large section of pipe C, we find that it stands almost if not quite at equal pressure with the one on top of the main, although it is ten feet from the main, whereas gauge No. 4, at the end of the small three-foot section, shows considerably less. What is the reason for this?

Again the answer is simple. The volume of water passing through the short pipe is very great as compared with its diameter. It is rushing through at high speed, therefore the friction or resistance encountered is high, with the result that pressure is used up very rapidly in forming the water against it. On the other hand, while precisely the same

volume or amount of water is passing through the large section of the pipe it is moving quite slowly, hence the resistance it encounters is comparatively slight, and very little power is necessary to overcome it.

The pressure at which the water might be would not affect the result, except that if it be very low not much resistance could be overcome. A pipe of given diameter will carry water up to its capacity (*the capacity of a pipe may be said to have been reached when its resistance to the flow of water becomes excessive, so that there is a considerable waste of power in forcing the water through*) under any pressure sufficient to move the liquid and less than that sufficient to burst the pipe. A pipe of given diameter will convey only a certain number of gallons of water per minute without excessive friction, regardless of whether the pressure be 10 or 100 pounds per square inch, but *when the point is reached where resistance to flow becomes excessive, the normal capacity of the pipe is said to have been reached.* True, we can still force a great deal more water through, but it will be at the expense of largely increased power consumption. It costs money to force a water pipe above its capacity, and the cost increases very rapidly in proportion to the excess of capacity; in other words, the higher the excess over capacity the greater the relative cost of overcoming the resistance.

The practical method of reducing this resistance is to increase the diameter of the pipe until the desired flow is had with only a normal friction loss. We therefore deduce the rule that:

Increasing the diameter decreases the friction, or resistance offered to a given flow, since the water is thus caused to move more slowly.

But another equation enters here, viz., the length of the pipe. Inasmuch as friction very largely results from the rough side of a pipe, it naturally follows that the longer the pipe the more friction there will be. We have already seen that with a given flow as the diameter of the pipe is decreased (made less), the friction or resistance is increased (made greater), and conversely, as the diameter of the pipe is increased (made greater) the friction or resistance is decreased (made less).

We may also readily see that, with a given flow:

As the length of the pipe is increased the friction (resistance) is increased, and, conversely, as the length is decreased the resistance is also made less.

Therefore, we may increase the resistance by (a) increasing the flow of water; (b) decreasing the diameter of the pipe;

(c) increasing the length of the pipe; (d) increasing its roughness.

We may decrease the resistance by (a) decreasing the flow; (b) increasing the diameter of the pipe; (c) making the pipe shorter; (d) making the pipe smoother.

All this is simple, and is or ought to be readily understandable. And now *what has been said of the water pipe is also true with relation to current and wires.* If you substitute circuits of wire for the water main and for pipes A, B, and C, with voltmeters in place of the pressure gauges, and lamps or motors instead of the open pipe-end you will get precisely the same relative result in loss of pressure (voltage) when current flow is sent through the circuits.

The voltage of the current has absolutely nothing whatever to do with the necessary size of wire. You could convey current at 10,000 volts, or 50,000 volts for that matter, on a No. 40 wire, which is no larger than a very fine silk thread, but on that wire you could convey a very small quantity—amperage.

Electric current in passing through wires encounters resistance precisely the same as does water in passing through a pipe. A wire of given diameter will convey a certain given number of amperes of current without excessive friction (resistance), just the same as a water pipe of given diameter will convey a certain given number of gallons of water without undue friction or resistance, and the point where resistance begins to rise above normal marks the "capacity" of the wire, just as it does the water pipe. Beyond that point the friction or resistance becomes excessive, and manifests itself in a loss of pressure or voltage. This loss in pressure has been consumed in forcing the current against resistance, precisely as was the case in the water pipe. It therefore follows that *loading wires beyond their normal capacity is expensive, and should be avoided for that if for no other reason, since the waste is registered on your meter and you will have to pay for it, exactly the same as you pay for current used in your lamps or motors.*

But this is not all, for if you attempt to force amperage in excess of the rated capacity, as shown by the Underwriters' table (see page 42), heat will be developed, and, if the matter be carried too far (which can only be done by overfusing), the wires may get red, or even white hot, finally burning in two entirely and stopping all current flow and perhaps setting fire to the building in the process.

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Exactly as was the case with the water pipe, with a given current flow the resistance of a wire is decreased as the diameter of the wire is increased, or its length made shorter, and is increased as the diameter of the wire is made smaller or its length decreased.

Resistance increases....With increased length of wire; or
As diameter is decreased; or
As the temperature is increased above normal; or
As the composition of the wire is changed to an alloy having lower conductivity.

Resistance decreases....As length of wire is decreased; or
As the diameter is increased.
As the temperature is reduced, if it be above normal.
As the composition of the wire is changed to an alloy having higher conductivity.

NOTE.—The difference in conductivity of different metals makes the analogy of water and current action more complete, since it corresponds to roughness or smoothness of walls of the water pipe.

Different metals offer varying resistance to electric current as follows, taking the resistance of pure silver and pure copper as 1.

Copper	1	*18% German Silver	19
Silver	1	Manganin	24
Aluminum	1.5	*30% German Silver	28
Platinum	6	*Advance Wire	28
Norway Iron	7	*Climax Wire	50
Soft Steel	8	*Nichrome	60
*Ferro Nickel	17		

NOTE.—The Driver-Harris Company, manufacturers of resistance wires, are authority for these figures. I know of no more reliable source for information of this kind. Star (*) indicates Driver-Harris products.

In the foregoing table the figures refer to the amount of resistance each metal has, as compared to that of pure, annealed copper. For instance, platinum has 6 and climax wire 50 times the resistance of pure, annealed copper.

I have selected for a part of this table metals and compositions in very general use for resistance purposes. It will, of course, be understood that the figures given in the tables are based on metals and alloys of a certain standard purity, but inasmuch as the degree of purity will, in the very nature of

things, vary to some extent, the figures cannot be relied upon for absolute accuracy.

It must also be understood that the resistance of nearly all metals increases with rise of temperature, whereas the resistance of carbon decreases as its temperature increases. The resistance of the carbon filament of the incandescent lamp of the ordinary type is about twice as much when cold as when burning at candle power. As a general proposition the resistance of liquids and insulating materials become less with increased temperature.

TEMPERATURE COEFFICIENT—HOW TO USE

The resistance of a wire is not constant at all temperatures. If you increase the temperature of a metallic wire you also increase its resistance, and this increase in resistance follows a definite law, viz.:

In metals increase or decrease in resistance is directly in proportion to increase or decrease in temperature.

The factor that will enable you to calculate this increase or decrease, provided you know the difference in temperature, is called the "temperature coefficient." In all catalogs of resistance wire the resistance per foot of the material is given at a certain standard temperature, usually 75 degrees F, and the resistance at this standard temperature will form the basis for calculation of increased or decreased resistance by reason of temperature change. The figure given for temperature coefficient is the fraction of an ohm change in resistance for each degree F change in temperature, and this coefficient must be multiplied by the number of degrees of the temperature change from the standard 75 degrees, and the result added to or subtracted from the standard resistance, depending upon whether the material increases in resistance with heat as metal does, or decreasing with heat as some other substances, carbon, for instance, do. For example, let us assume the temperature coefficient of a given material to be .001 per degree F., and that its resistance at 75 degrees F. is 10 ohms. What will be its resistance at 175 degrees.?

Subtracting 75 from 175 we find the difference in temperature to be 100 degrees. If the resistance increases .001 of an ohm for each degree of increased temperature then for 100 degrees increase of temperature the increase of resistance would be $.001 \times 100 = .1$. Now, multiply the resistance (10 ohms) at 75 degrees by the fractional increase, which is .1,

which gives us the actual total increase of $10 \times .1 = 1$ ohm, so that the resistance at 175 degrees F will be 10 ohms, the standard resistance, plus 1 ohm increase, or a total of 11 ohms.

PROPERTIES OF CONDUCTORS

Electric conductors are ordinarily selected with one of two ends in view. In one case low resistance, tensile strength, ductility, and cost are the ruling factors; in the other case comparatively high and steady resistance is the important item.

In the first instance conductors for current distribution is the thing considered, and, by reason of the fact that it more nearly combines the four above-named important factors than any other metal, copper has been selected as the standard electrical conductor, an office which it shares only, to some slight extent, with aluminum, the latter being used in a few instances for high tension lines.

In the second instance a material to offer resistance is the thing desired, and for a long time the metal used almost exclusively for this purpose was German silver. Gradually, however, German silver has been largely displaced, until it is now but little used except in alloy combinations with other metals.

The materials now most generally used for resistance in motion picture projector circuits are either cast iron, made up in grid form, or some one of the nickel-steel resistance wires. Reliable data concerning the properties of cast iron is difficult, in fact practically impossible to obtain, but it may be said that it forms an excellent and cheap resistance medium where considerable variation at different temperature is not of great importance.

Properties of Resistance Metals.—"Normal" is 75° F. or 24° C. The resistance per mill-foot of pure nickel is 64.3 ohms at normal. Climax resistance wire, made by the Driver-Harris Company, Harrison, N. J., has a resistance per mill-foot of 525 ohms at normal; its temperature coefficient is .0004 per degree F. It is a nickel steel alloy with a resistance fifty times that of copper. This metal is excellent for rheostat coils.

German silver is a composition containing 18 per cent. of nickel. It is known as "18 per cent. German silver." Its resistance varies somewhat with different lots. Its mill-foot resistance is 218 ohms at normal; its temperature coefficient .00017 per degree F.

Ferro nickel has a mill-foot resistance of 170 ohms at normal; temperature coefficient is .00115 per degree F.

Yankee silver is a new alloy, put out by the Driver-Harris firm, which is claimed to be an improvement on the 18 per cent. German silver in that it withstands rapid heating and cooling well, and gives good service where German silver fails. Its resistance is 200 ohms per mill-foot; its temperature coefficient is very low, being .000086 per degree F.

Nichrome, also a Driver-Harris product, is a practically non-corrosive alloy with high melting point—about 2600 degrees F. It is designed for use where high temperatures are the rule, such as heating coils, etc. Its mill-foot resistance is 600 ohms; its temperature coefficient .00024 per degree F.

Advance wire, a Driver-Harris product, is a copper-nickel alloy containing no zinc. It is claimed to be constant in its resistance under all conditions of service; therefore it has no temperature coefficient. Resistance per mill-foot is 294 ohms. It is particularly recommended for electrical instruments where the resistance is subjected to repeated heating and cooling.

LOSS THROUGH RESISTANCE

It is highly desirable and under certain conditions very necessary that the operator be able to figure the resistance of the various circuits in the theatre or of the feed-wires leading thereto. As has already been pointed out, the overcoming of resistance consumes voltage. All wires offer resistance to current, and voltage will be consumed in (a) proportion to the size of the wire; (b) the length of the wire; (c) the amount of current flowing; (d) composition of the wire.

Up to a certain point the resistance of the wire remains without change; that is to say, the resistance offered to one ampere or ten amperes will be identical, but when the load becomes such that the temperature of the wire begins to rise, then the resistance also begins to rise, and the effect is, as has already been explained, a loss in voltage, with the result that the lamps will not burn to candle power and the meter is registering wattage which is being wasted in overcoming the excessive resistance of the wires.

Copper wire used for electric current can carry a certain number of amperes without causing any appreciable rise in temperature, and the National Board of Fire Underwriters, which is the controlling factor, has adopted the amperage rating recommended by the American Institute of Electrical Engineers. This determines the number of amperes which

any wire may be allowed to carry, which are set forth in Table No. 1, in which "B. & S." means "Brown & Sharpe Wire Gauge." For reasons why more current is allowed on weather-proof than on rubber-covered see "Insulation," page 50.

TABLE NO. 1. WIRE CAPACITIES.

B. & S.	Rubber Insulation Amperes	Other Insulations Amperes	Circular Mills
18	3	5	1,624
16	6	10	2,583
14	15	20	4,107
12	20	25	6,530
10	25	30	10,380
8	35	50	16,510
6	50	70	26,250
5	55	80	33,088
4	70	90	41,740
3	80	100	52,630
2	90	125	66,370
1	100	150	83,690
0	125	200	105,500
00	150	225	133,100
000	175	275	167,800
0000	225	325	211,600

For insulated aluminum allow 84 per cent. of above table ratings. The Board of Fire Underwriters does not recognize anything of less size than No. 18 wire, and nothing less than No. 14 can be used for interior circuit wires.

The figuring of the resistance of a wire of any size or length is a simple matter, provided the standard of resistance for that particular material be known.

MILL-FOOT STANDARD OF RESISTANCE

The accepted standard of resistance is the resistance of a wire one circular mill in cross-section (one one-thousandth of an inch in diameter) and one foot in length, made of the same material as the wire it is proposed to measure. This is what is known as the "Mill-foot standard of resistance." The resistance of such a wire, when made of ordinary commercial copper, is given by standard text books as 10.5 ohms. That is to say, a wire one foot in length and one one-thousandth of an inch in diameter (one mill cross-section), made of ordinary commercial copper, at normal temperature (75° F. or 24° C.), will have a resistance of 10.5 ohms.

TABLE NO. 2

RESISTANCE OF COPPER WIRE

Am. Gauge, B. & S. No.	Resistance at 75° F., International Units			
	R. Ohms per 1000 Feet	Ohms per Mile	Feet per Ohm	Ohms per Lb.
000000	0.03122	0.1649	32036.	0.00003070
00000	0.03937	0.2079	25398.	0.00004881
0000	0.04964	0.2621	20147.	0.00007758
000	0.06261	0.3306	15972.	0.0001234
00	0.07894	0.4168	12668.	0.0001962
0	0.09945	0.5251	10055.	0.0003114
1	0.1255	0.6627	7968.	0.0004960
2	0.1583	0.8360	6316.	0.0007894
3	0.1966	1.054	5010.	0.001254
4	0.2516	1.329	3974.	0.001994
5	0.3174	1.676	3150.	0.003173
6	0.4002	2.113	2499.	0.005043
7	0.5044	2.663	1982.	0.008013
8	0.6361	3.358	1572.	0.01274
9	0.8026	4.238	1246.	0.02029
10	1.011	5.340	988.8	0.03220
11	1.277	6.743	783.1	0.05135
12	1.609	8.496	621.5	0.08154
13	2.026	10.70	493.6	0.1293
14	2.556	13.50	391.2	0.2058
15	3.221	17.01	310.4	0.3268
16	4.070	21.49	245.7	0.5216
17	5.118	27.02	195.4	0.8249
18	6.466	34.14	154.6	1.317
19	8.151	43.04	122.7	2.092
20	10.26	54.15	97.51	3.312
21	12.93	68.26	77.35	5.263
22	16.41	86.62	60.95	8.476
23	20.56	108.6	48.63	13.32
24	26.00	137.3	38.47	21.28
25	32.78	173.1	30.51	33.84
26	41.54	219.4	24.07	54.35
27	52.09	275.0	19.20	85.44
28	66.17	349.4	15.11	137.9
29	82.27	434.4	12.15	213.1
30	105.1	554.7	9.519	347.6
31	131.7	695.4	7.592	546.3
32	166.2	877.4	6.018	869.6
33	209.5	1106.	4.772	1383.
34	264.6	1397.	3.779	2205.
35	333.7	1762.	2.996	3507.
36	420.1	2218.	2.380	5558.
37	530.4	2801.	1.885	8860.
38	669.9	3537.	1.493	14131.
39	843.0	4451.	1.186	22378.
40	1065.	5625.	0.9387	35734.

FIGURING RESISTANCE OF CIRCUITS

And now let us proceed to apply the foot-mill standard in measuring wires. Suppose you have a wire 400 feet in length and 1 mill-foot in cross-section (1/1000 of an inch in diameter) made of ordinary commercial copper. It is evident that if one foot of such a wire has a resistance of 10.5 ohms, 400 feet would have a resistance four hundred times as great, or $10.5 \times 400 = 4200$ ohms. The resistance of a wire of given length, however, decreases, as its diameter, area or cross-section is increased. Now if our 400-foot wire has a diameter of 250 mills it will have a cross-section equal to $250 \times 250 =$ 62,500 C. M., and it follows that its resistance would be equal to the resistance of 400 feet of one-mill wire (4,200 ohms) divided by the C. M., cross-section of the larger wire (62,500), since it would be, in effect, equal to 62,500 wires, each one circular mill in cross-section, or one mill in diameter. From this we get the rule:

To find the resistance of a copper wire, multiply its length in feet by 10.5 *and divide that product by its area in circular mills.*

In measuring circuits, however, it is customary to take the one way length and double the mill-foot standard, thus: multiply the one way length of the circuit by 21 ($10.5 \times 2 = 21$) *and divide that product by the area of the wire in the circuit; expressed in circular mills.*

For example: What is the resistance of a two-wire operating room feed circuit 300 feet in length—size of the wire No. 5? Now if we were just measuring one 300-foot-long wire we would apply the above rule, using 10.5 as the standard of resistance, but as a matter of fact a circuit 300 feet long has 600 feet of wire, and, for convenience sake, we double the mill-foot standard, instead of doubling the wire length.

In Table 1, page 42, we find that No. 5 wire has a cross-section of 33,088 C. M. We then have the problem:

$$\frac{\text{Length of circuit} \times 21}{\text{Area of wire}} = \frac{300 \times 21}{33{,}088} = 1874\text{, or say .2 of an ohm,}$$

which is the resistance of the circuit. This rule is, of course, based on the proposition that the wire will not exceed 75 degrees F., or 24 degrees C. However, the rise and fall in temperature caused by ordinary climatic conditions is not sufficient to effect the result materially. In fact, resistance does not begin to rise appreciably until the temperature has increased sufficiently to be sensible to the feeling; beyond that point it increases very rapidly with the temperature.

The foregoing is good for any number of amperes up to the capacity of the wire, or, in other words, until the load becomes great enough to cause a distinct rise in temperature. For instance: If you propose to carry only 5 amperes on a No. 5 wire you would have exactly the same total resistance you would have if you pulled 50.

Theoretically this is not strictly true, since there is a rise in temperature with *any* increase in current, but it is true in practice, nevertheless, by reason of the fact that with any load less than the wire's capacity the temperature rise is too slight to have appreciable effect.

When figuring copper wire resistance still another equation enters, however, and a very important one, too, viz., drop in voltage.

FIGURING VOLTAGE DROP

It has been laid down as a general rule that:

For the transmission of any given amperage the most economical condition is one where the line resistance is of such value that the value of the energy wasted in heat in overcoming the resistance of the line will be equal to the interest per annum on the original cost of the conductor.

The question of drop in voltage in theatre circuits is usually given too little consideration. Where the length of the circuit, the cross-section, or area of the wire, together with its mill-foot standard of resistance, is known, the ohmic resistance may be calculated according to:

Formula No. 1: $$R = \frac{21 \times L}{A}$$

in which R is resistance in ohms; L the one-way length of the circuit, expressed in feet; A the cross-section, or area of the wire in circular mills, and 21 a constant equal to twice the resistance of the mill-foot standard for copper wire. Twenty-one and the one-way length of the circuit are used, instead of 10.5 and the total length of the two wires, merely for the sake of convenience.

Formula No 2: $e = I \times R$

in which e is the voltage drop; I the current in amperes, and R the resistance of the circuit.

Formula No. 3: $$e = \frac{21 \times I \times L}{A} \text{ in volts.}$$

Formula No. 4: $A = \dfrac{21 \times I \times L}{e}$ in circular mills.

Formula No. 5: $I = \dfrac{e \times E}{21 \times L}$ in amperes.

Formula No. 6: $L = \dfrac{e \times A}{21 \times I}$ in feet.

When it is required to give a working formula for a given number of lamps expressed by N, each of which requires amperes represented by I, use Formula No. 7.

Formula No. 7: $A = \dfrac{21 \times N \times I \times L}{e}$ area in circular mills.

When the drop is expressed as a percentage, the size of the wire may be determined by Formula No. 8.

Formula No. 8: $A = \dfrac{21\cancel{00} \times I \times L}{E \times P}$ area in circular mills, E being the voltage of the circuit and P the percentage drop.

Where, as is often the case, the power, W, is given in watts instead of amperes, use Formula No. 9.

Formula No. 9: $A = \dfrac{21\cancel{00} \times W \times L}{P \times E}$ area in circular mills.

If it is desired to find the number of lamps to which a given size of wire will supply current with a given drop use Formula No. 10.

Formula No. 10: $N = \dfrac{A \times e}{21 \times L \times I}$

Applying formula No. 2, let us assume a current of 100 amperes in a circuit whose resistance figures .02 of an ohm. Multiplying 100 amperes by .02 we get 2 volts as the drop in that circuit. Formulas Nos. 3, 4, 5, 6, 7, 8, 9, and 10 are obtained by substituting the value of R in Formula No. 2 for R in Formula No. 1. Also for convenience L (length of circuit)

is made equal to 2L, so that only the distance one way need be considered.

And now let us assume an example. A two-wire operating room feeder supplies 50 amperes at a distance of 200 feet from the house switchboard; the drop allowed is 5 per cent., the voltage 110. What size wire should be used? Referring to the formula, we select No. 8, and, substituting figures, the necessary size of wire is found as follows:

$$A = \frac{21\cancel{00} \times 50 \times 200}{110 \times .05} = 38181 \text{ circular mills.}$$

Turning to our capacity table we find that a No. 4 wire has an area of 41738 C.M. and a No. 3 has 52624, so that a No. 3 would be largely in excess of the requirements and a No. 4 would be too small.

If this energy were used for ten hours a day for 300 days and the cost of the energy were 8 cents per k.w. hours, the total yearly cost would be:

$$\frac{50 \times 110 \times 300 \times .08}{1000} = \$1{,}320$$

five per cent. of which is $66, which latter amount would express a yearly loss due to the 5 per cent. drop when using 50 amperes at 110 volts. The cost of 400 feet of No. 4 wire would be about $21, hence the yearly loss would be more than three times the cost of the wire, and, without further calculation, it is very readily seen that No. 4 wire would not be economical for this service. If, on the other hand, wires sufficiently large to only cause a four per cent. loss be used, it is no difficult matter to figure out the saving and discover the fact that it would considerably more than pay interest on the added copper cost with current at 8 cents per kilowatt. Suppose, however, the price of electricity were 6 cents per k.w. instead of 8. The installation of such a large cable would then not be profitable, since the saving would be less, hence, less investment in copper would be necessary.

This data is of much importance to both operator and manager, because by the use of the B. & S. wire gauge and a tape line they will be able to figure out the approximate loss in their various circuits, and in many instances it will be found that they are paying heavily for energy wasted in line resistance. There are many operating room feed circuits that are giving a 5 per cent. drop, or even larger than that, and all this

waste energy is registered on the wattmeter. Therefore, I repeat, it is essential that the operator and manager have a good working knowledge of questions of this kind.

Note: In the foregoing I neglected to include increase of cost for installing larger wires. This must be added to initial cost of wire in order to arrive at the correct result.

Further data on resistance as applied to the projection lamp arc circuit will be found under the head, "Resistance Devices."

Measuring Wires

ELECTRIC conductors of various kinds are measured as to their cross-section or area in square and circular mills, circular mills being used for round wires and square mills for square or rectangular conductors.

A square measuring 1/1000 *of an inch on each of its four sides is called a "square mill." A circle* 1/1000 *of an inch in diameter is called a "circular mill,"* commonly designated "C.M."

A round wire 1/1000 of an inch in diameter is said to have an area of cross-section of one circular mill.

The areas of all round wires are directly proportioned to the square of their diameters, the calculation being made in mills (thousandths of an inch).

"Squaring the diameter" means multiplying the diameter by itself.

It therefore follows, if the areas of the circles are proportional to the squares of their diameters, and the area of a wire one mill in diameter is called one mill, or one "circular mill" (C.M.), then wires of other sizes have an area of cross-section, numerically equal, in circular mills, to their diameter in one one-thousandths of an inch (mills) squared, or multiplied by itself, thus: If a wire be 10 mills in diameter, then 100 (10×10) is the "square" of its diameter, hence its area of cross-section in C.M.

Let us also consider a wire one-quarter of an inch in diameter. Since the wire is one-quarter inch in diameter, and one inch is equal to 1000/1000, then the diameter of the wire expressed in thousandths of an inch, or mills, would be equal to $1000 \div 4 = 250$. Such a wire would then be 250/1000 of an inch in diameter, or, expressed otherwise, 250 mills in diameter. And since the area of cross-section of a wire in circular mills is equal to its diameter in mills multiplied by itself (squared), it follows that the area of the wire in question would be $250 \times 250 = 62{,}500$ circular mills.

The circular mill area of any round wire may be found by measuring its diameter in thousandths of an inch, using a micrometer caliper or wire gauge for the purpose, and multiplying the measurement thus obtained by itself.

There are several methods of measuring wires. The accepted standard for wire measurement in this country is the American Gauge, commonly known as the "Brown & Sharpe Gauge," and in practice dubbed the "B. & S." gauge, the same being illustrated in Fig. 7.

In using this tool it is the slot and *not* the round hole that determines the size of the wire, and while the wire must not actually bind in the slot, it must fit snugly. The gauge, if it

Figure 7.

be a good one, will have the width of each slot, or, in other words, the diameter of the wire which fits the slot, stamped opposite each slot on one side of the gauge, and the number of the wire stamped opposite the slot on the other. In Fig. 7 it is the wire number side we see. The diameter in thousandths of an inch is the same thing as the diameter in mills. For instance, No. 16 wire has a diameter of fifty-one thousandths of an inch, or, in other words, 51 mills, the term thousandths of an inch and mills being interchangeable.

One of the most convenient and at the same time most accurate methods of measuring wire is by means of a micrometer caliper. See Fig. 8. These calipers may now be had with the wire size and their equivalents in mills (thou-

sandths of an inch) stamped thereon. For instance, in the illustration we see "4/0," with 460.0 opposite it, which means that 0000 (called "four 0") wire is 460 mills (460 thousandths of an inch) in diameter. These tools are expensive, but, on the other hand, they are mighty good articles to own, and ought to be included, in one form or another, in every operator's tool kit.

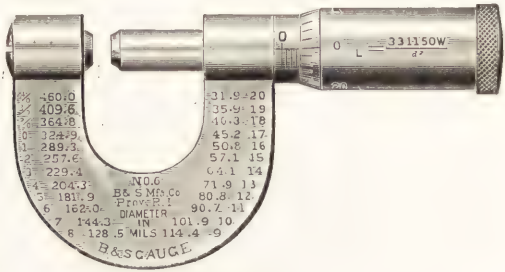


Figure 8.

For measuring very small wires, such as the strands of an asbestos-covered wire (usually No. 30 or 31), the slot wire gauge is not very reliable except in the hands of an expert. If you have no micrometer caliper it is better to have a machinist make the measurement for you with his. Have measurements made of three or four strands from different parts of the wire.

For most purposes, however, the wire gauge, in conjunction with the wire capacity table, page 42, will answer all purposes.

Insulation

WHEN there is a difference in potential maintained between two wires of an electric circuit these wires have an affinity for each other and current seeks constantly to pass from one to the other. The purpose of insulation is to prevent this and to keep the wires from coming into electrical contact with any object which might furnish an electrical path to a wire of opposite polarity attached to the same dynamo. Such a path may be found through the ground or through any current-carrying material having electrical contact with wires of opposite polarity. In short, insulation is to protect the potential of or on a wire interference by any outside source.

As we have already seen (page 38), various metals offer varying resistance to the passage of electric current. Not only is this true, but various materials other than metals offer varying resistance to the passage of electric current, and, while there is no material which is a non-conductor—that is to say, through which electric current cannot be forced if the pressure (voltage) be raised sufficiently high, still there are materials which are considered and treated as non-conductors, because no ordinary voltage will force current through them. These substances are called "insulating materials," at the head of which stand, in the order named, glass, procelain, and rubber. Various natural substances such as marble and slate form excellent insulating materials, and asbestos, when dry, is also a very good insulator. There are also various insulating compounds, the composition of which are trade secrets. In practice these compounds are used to saturate some kind of braided or other material which, after being so saturated, is used for weatherproof insulation on wires to be used out of doors, or to reinforce the rubber insulation of rubber covered wires.

Procelain is, for the most part, used to line holes in brick or other walls through which it is necessary to pass wires and for knobs to carry wires which are run in open circuit through the air, or along walls. Rubber, on the other hand, is, for the most part, used for inner insulation of what is called "rubber covered" insulation of wires. Glass is used only for pole insulators on low potential, owing to its fragile nature.

Rubber covered wire consists of tinned copper wire with a covering of rubber or rubber compound of homogeneous character, reinforced by an outer covering of braided cotton soaked in preservative insulating compound. Where copper wire is covered with any of the rubber compounds the tinning of the wire is very necessary, since the sulphur universally present in rubber insulation is likely to combine with the copper and in a short time the wire would be corroded, and either very greatly weakened or, if a small wire, entirely destroyed. The tinning of the wire prevents this, since tin will not combine with sulphur and the rubber insulation has no effect upon it.

It is not, however, the purpose of this book to go into an exhaustive treatise on insulation materials, but merely to give the operator a general understanding of the proposition.

The current must be confined to the wire and made to pass from the positive to the negative through the paths provided,

and through them only, the said paths being motors, incandescent globes, arc lamps, etc. The strength of insulation must increase with the potential, and its kind may vary with the service. For instance: the insulation known as "weatherproof" may be used where the wires are stretched in open air on out-door circuits. On the other hand, for interior work while this same insulation may still be used, underneath it and next the wire there must be a coating of pure rubber or rubber compound. The insulation then becomes what is known as "rubber covered." Its disadvantage lies in the fact that rubber deteriorates rapidly under the influence of even moderate heat, and is immediately destroyed by anything like high temperature. The necessary strength of the insulation, either weatherproof or rubber covered, will depend upon the voltage.

There are several ways of testing the insulation of wires, the test here given being that required by the National Board of Fire Underwriters for rubber covered wire.

TESTING INSULATION

Any one-foot sample of completed covering must show a dielectric (dielectric is defined as any substance or medium that transmits the electric force by a process different from conduction, as in the phenomena of induction; a non-conductor separating a body electrified by induction from the electrifying body) strength sufficient to resist, for a period of five minutes, the application of voltage proportionate to the thickness of the insulation, in accordance with the following table:

TABLE NO. 3

Thickness in 64th inches	Breakdown test on 1 foot Volts A. C.
1	3000
2	6000
3	9000
4	11000
5	13000
6	15000
7	16500
8	18000
10	21000
12	23500
14	26000
16	28000

In making the foregoing test the source of electro-motive force (voltage) must be a transformer of at least one kilowatt capacity. The application of the electro-motive force shall be made at 3000 volts for five minutes, and then the voltage must be increased by steps of not more than 3000 volts each, the voltage of each step being held for five minutes until the maximum for a given thickness of insulation is had, or until there is a rupture of the insulation. The test for dielectric strength must be made on wire which has been immersed in water for seventy-two hours, one foot of the wire under test to be submerged in a conducting liquid held in a metal trough, one of the transformer terminals being connected to the copper of the wire, and the other to the metal of the trough.

There are two types of weather-proof wire, viz.: weather-proof and slow-burning weather-proof. The insulation of the slow-burning weather-proof consists of two coatings, one of which is fire-proof in character, while the other is not. The fire-proof coating is on the outside and comprises about six-tenths of the total thickness of the insulation. The complete covering for sizes of wire from No. 14 to No. 0000 varies from 3/64 to 5/64 of an inch. The fire-proof insulation is not as susceptible to fire as is ordinary weather-proof, nor does it as readily soften under the influence of heat. It is not suitable, however, for outside work, being intended for interior work in dry, warm places such as shops and factories. There is another type of wire insulation called "slow-burning," which is still more fire-proof than is the slow-burning weather-proof. It is intended to be used in very hot places where ordinary insulation would soon perish. The insulation of weather-proof wire should consist of at least three layers of braid, each of which is thoroughly saturated with a dense, moisture-proof compound, applied in such manner as to drive any atmospheric moisture out of the cotton braiding, thereby securing a covering to a great degree water-proof and of high insulating power. The outer surface of this insulation is pressed down to a hard, dense surface. This wire is for use out of doors where moisture is certain and where fire-proof qualities are not necessary. In general, weather-proof wires can be used only where the insulating supports on which the wire is mounted are depended on for insulation, the covering being regarded simply as a precaution against accidental contact with other wires or other objects.

From the foregoing it will readily be understood that the principal difference between rubber-covered and other insulation lies in the fact that the rubber-covered insulation may be depended upon entirely for insulating, whereas the others must depend, at least to a considerable extent, on the insulating supports for their insulation. Rubber-covered wire may be used in any place that weather-proof would be allowable, but not in places where slow-burning insulation would be required. *Double braid rubber-covered wire is the only kind that may be used in conduits, where the two wires of the circuit lie side by side.* So far as the carrying capacity of copper be concerned it makes absolutely no difference what the insulation be composed of. The reason that rubber-covered wire is rated at lower capacity than weather-proof is by reason of the fact that rubber is easily injured by even moderate heat, hence when it is used a high margin of safety is maintained.

Under no circumstances is it permissible to use other than wire having rubber-covered insulation inside of conduits.

Wire Systems

IT is highly desirable that the operator have a good working knowledge of the various wire systems with which he is likely to come in contact. It is not the purpose of this work to make the operator a wireman, or an electrician for that matter, but merely to give him a fairly comprehensive general idea of the action of electric current and the appliances, including the wire systems, with which he will have to do.

On the road, particularly when playing small towns. the operator may be called upon to connect to any one of the several different wire systems, and unless posessed of knowledge he will be unable to proceed with any degree of certainty or confidence.

There is one wire system with which it is impractical—I might even say impossible—to connect a projection arc, viz, the series arc system. This system is used only for street arc lighting. Instead of two wires it only has one, and each lamp carries the entire amperage of the system, or circuit. The voltage of the series arc system will depend upon the number of lamps, there being an added pressure of about 50 volts for each lamp, so that a circuit supplying ten lamps would have a pressure or voltage of $50 \times 10 = 500$ volts, whereas if there were eleven lamps the pressure would be $50 \times 11 = 550$,

and so on. Do not attempt to connect your projection lamp to the series arc system, because if you do you will fail; also you will cause serious trouble, and may succeed in getting yourself badly shocked, or possibly even killed. Fig. 9 is a diagrammatic representation of a 10 lamp series arc system.

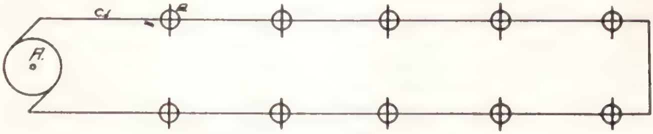


Figure 9.

There was at one time a system called the "series-multiple" and another called the "multiple-series," but with these it is unnecessary, I think, to deal, since they have been practically if not entirely abandoned.

TWO-WIRE SYSTEM

The "multiple arc system," also called the "two-wire system," is, to all intents and purposes, the only one with which the operator comes into contact, the three-wire system being but a variation of the two-wire system, so far as electrical action and practical effect be concerned.

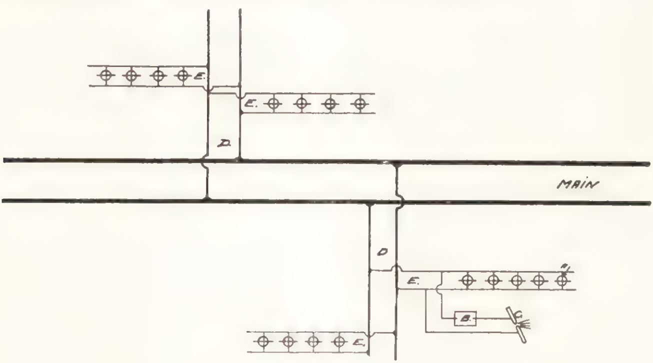


Figure 10.

In Fig. 10 we see diagrammatic representation of what is varyingly styled the "multiple arc," "parallel" and "two-wire" system. The heavy lines represent mains coming from

the power house, the less heavy ones, D-D, branch mains feeding a district or street, and the thin lines, E-E-E, house, store, theatre circuits, etc. In theory the current flows out from the dynamo on the positive wire, through the various lamps, etc., to the negative, and back on it to the dynamo.

In one of the house circuits a projection lamp is attached, all switches, fuses, etc., being omitted for convenience. Assuming that the system carries not more than 500 volts we may attach a projection lamp to the wires at any point, provided (a) the wires, switches, etc., be large enough to carry the current necessary for the arc, plus whatever else they will have to carry, without overload; (b) the fuses be large enough to carry current for the arc, plus whatever else it will have to carry; (d) provided sufficient resistance be connected in series with the lamp to reduce the line voltage to arc voltage.

If the system be D. C. the voltage will not, in any event, exceed 500, and, except in the case of power lines for street car service, seldom goes above 220.

If the current be alternating then you can attach your projection lamp at any point, provided the same precautions be taken as before named for D. C., but if the line be what is called high tension (1000 volts or more), then you can only attach your projection lamp on the secondary side of a transformer. In this connection the traveling operator should always have a copy of McGraw's Electrical Directory, which is for sale by McGraw Publishing Company, 239 West Thirty-ninth Street, New York City, costs $10 a year, and gives particulars of every light plant in the country. If he is not the possessor of this book, then the first thing for him to do upon entering a town is to call up the power house and ask: (a) the kind of system; (b) voltage of the system; (c) if the show is to be given in a church, school house, or hall, and the current is A. C., and whether or not the transformer supplying the building in which the show is to be given is large enough to supply the projection arc, plus whatever else it has to supply.

THREE-WIRE SYSTEM

The three-wire system is a very popular and widely used method of electric light and power distribution. Its basic principle is the fact that if two batteries or two generators, of the same voltage, be connected in series with each other, the voltage between the positive terminal of one generator

or battery and the negative terminal of the other generator or battery will be double the voltage of either battery or dynamo separately. Thus if each dynamo be a 110 volt generator, then the voltage between the positive of one machine and the negative of the other would be 220 volts, but if, at the same time, the voltage be taken across the positive and negative brush of either machine separately, the reading will be only 110, or whatever the voltage of the individual machines may be. It therefore follows that if a wire be attached to the positive of one generator and the negative of the other generator, the voltage between these two wires will be double the voltage of either generator taken separately, and if a third wire be attached to the jumper connecting the two generators the voltage between either of the outside wires and the center wire (called the "neutral") will only be the voltage of the individual dynamo, or half the pressure between the two outside wires.

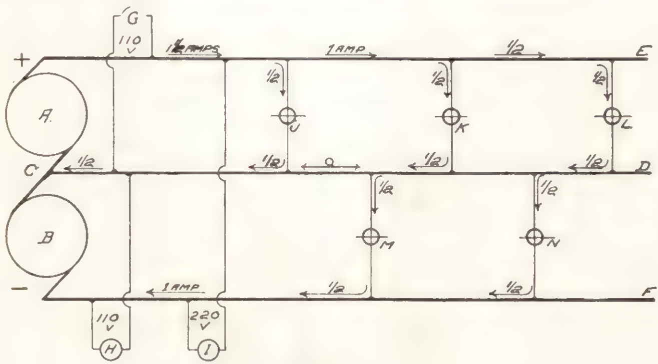


Figure 11.

In Fig. 11 A and B are 110 volt generators; C is a jumper connecting the negative terminal of machine A with the positive terminal of machine B; D is a wire attached to jumper C, the same being called the "neutral" wire; E is a wire attached to the positive terminal of generator A; F is a wire attached to the negative terminal of generator B; G is a voltmeter attached between wires E and D; H is another voltmeter attached between D and F, and I is a third voltmeter attached between wires E and F. Assuming generators A and B to be 110 volt machines then voltmeters G and H will each read 110, whereas voltmeter I will read 220. If

generators A and B were each 70 volt machines, then voltmeters G and H would each read 70, whereas voltmeter I would read 140. Still referring to Fig. 11, J, K, L, M, and N are ordinary 16 c.p. incandescent globes, requiring, let us assume, half an ampere of current each.

The electrical action is as follows: For the moment switching off globes J, L and N let us consider only lamps K and M. Under this condition a half ampere of current at 220 volts pressure would pass out from the positive brush of generator A, along wire E to lamp K, which is a 110 volt lamp, as is also lamp M, therefore the combined resistance of the two lamp filaments will be just sufficient to allow a half ampere of current to flow. Thus a half ampere passes through lamp K, into the neutral wire and back toward the generator, but instead of traveling on and into jumper C, it switches off, goes through lamp M and thence back on wire F to the negative terminal of generator B. In other words, lamps K and M burn in series with each other, and under this condition no current at all passes over the neutral wire between lamp M and jumper C.

Now, taking a step further, let us consider J, K and L. Each lamp requires, let us assume, 55 watts; therefore, $55 \times 3 = 165$ watts, divided by $110 = 1\frac{1}{2}$ amperes passes out on wire E, through the lamps, into the neutral and starts back thereon, but 55 watts (½ ampere) passes through lamp M, and another 55 watts (½ ampere) passes through lamp N into wire F, which accounts for one ampere, and leaves 55 watts (½ ampere) yet to be accounted for, which must pass back to the negative terminal of generator A, over the neutral wire, D, so that under this condition (called an "unbalanced system") we have 1½ amperes flowing on wire E, 1 ampere on wire F, and ½ ampere on wire D. For the sake of added clearness I have mapped out the course of the current with arrows which indicate the current flow.

In figuring the amperage of a 110-220 volt three-wire system remember this:

If you have 110 volt lamps or motors on one side rated at a given number of amperes you can add 110 volt apparatus of equal capacity on the other side without increasing the number of amperes flowing in the system. The electrical effect is the same as though you removed the 110 volt apparatus from the first side and substituted 220 volt apparatus of double h. p., connected between the two outside wires.

With a three-wire 110-220 volt system either 110 volt or 220 volt apparatus may be used. If you connect a motor or

lamp from either outside wire to the neutral it must be a 110 volt motor or lamp; if you connect a motor or lamp from outside to outside wire it must be a 220 volt motor or lamp, always assuming the generators to be 110 volt machines, as they are in practically all cases.

The ideal condition with a three-wire system presumes it to be perfectly "balanced," meaning by this that 110 volt apparatus (motors and lamps) drawing the same total amperage be connected to both sides. If in a light and power system there is 110 volt apparatus connected to one side, wires E and D, Fig. 11, drawing a total of 240 amperes, then there should be 110 volt apparatus connected to the other side, wires D and F, Fig. 11, sufficient to use 240 amperes. Under this condition the system would be perfectly balanced, and all apparatus would work in series, so that, so far as the actual operation of the lamps and motors be concerned, the neutral wire might be disconnected from the dynamo entirely. In other words, if the neutral fuse at the power house blew, or was removed, there would be no effect at all. The total amperes would only be 240.

This ideal condition is, however, seldom or never realized in practice. There is practically always more load on one side than on the other, and amperage equal to the difference between the load on the two sides flows back to the generator on the neutral wire. If there are 26400 watts being used on one side and 24200 on the other, then $26400 - 24200 = 2200 \div 110 = 20$ amperes would flow back to the generator on the neutral wire, and the practical effect would be that one generator would be producing 20 amperes more than the other.

It is for this very excellent reason that heavily loaded systems often object to projection arcs being connected to one side of the system. Both dynamos are working up to their capacity, and if a projection arc pulling, say, 40 amperes be hitched to one side its load is all thrown on one dynamo and the system is thus unbalanced. However, if the operator is reducing his voltage with a rheostat it would not help matters in the least to connect across the outside wires, since, although the amperage would remain the same the generators must put out double the amount of energy, and instead of having one dynamo loaded that much heavier, we have both carrying an additional load equal to amperage times 220, one-half of which is carried by each generator, which represents pure, unadulterated waste. If an economizer, a mercury arc rectifier, or a motor generator set be used,

however, then it is different, since the total energy taken from the lines will be practically the same when connected across on 220 as it would on one (110 volt) side.

It may be said that, as a matter of fact, *if you use a rheostat for resistance the power company can have no reasonable excuse for compelling you to attach your projection arc to the outside wires of a three-wire system.* It simply costs you that much more, and does not relieve the power plant in the least; in fact it adds to the total load.

The operator encounters some very puzzling questions in connection with the three-wire system. For instance.

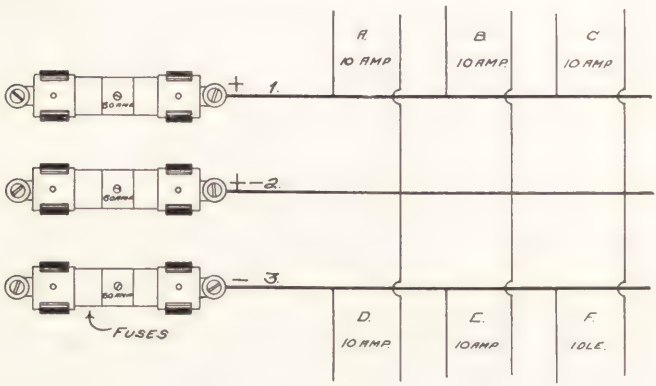


Figure 12.

In Fig. 12 we see a three-wire system fused at 60 amperes. From these lines are taken six circuits A, B, C, D, E, and F, five of which have apparatus attached to them requiring 10 amperes of current each. Now with those 60 ampere fuses would it be possible to attach a 25 ampere projection arc to the idle circuit F? At first glance you may say No; you are already pulling 50 amperes, since 5 $\times$ 10 makes 50, and right there you make a mistake, because you are not doing anything of the sort. You are pulling a total of 20 amperes across the outside wires, and 10 additional amperes on one side, so that fuse 1 carries 30, fuse 2 10 and fuse 3 20 amperes, therefore on the side that the idle circuit is on you are only pulling 20 amperes, and if you attach a 25 ampere arc you will still have a leeway of 15 amperes. Why?

The answer is simple. It is purely a question of wattage. One side has 110 volt apparatus requiring a total of $20 \times 110 = 2200$ watts. The other side requires $30 \times 110 = 3300$ watts. The current comes out on wire 1, at 220 volts pressure. It is forced through the 110 volt motor and lamps, 110 volts of the pressure being consumed in so doing. It is then on the neutral wire, still 30 amperes, but at 110 volts pressure; therefore it still has power equal to $110 \times 30 = 3300$ watts. Now the neutral is negative to wire 1 but positive to wire 3, and *wire 3 is the* TRUE negative of the combination. Therefore, there is still the inclination to seek the negative (*true* negative), but the apparatus connecting wires 2 and 3 only requires $110 \times 20 = 2200$ watts, so that when they have been supplied 10 amperes $10 \times 110 = 1100$ watts remain, and, being unable to reach the true negative, wire 3, must pass back to the generator on wire 2, the neutral, and thus we find that the apparatus on both sides has been supplied by the 30 amperes, and in such manner that fuse 1 carries 30, fuse 2 10, and fuse 3 20 amperes.

As soon, however, as we attach a 25 ampere arc to F, the 10 amperes overbalance from the other side ceases to flow back over the neutral and begins to burn in series with the arc, which makes 30 amperes on the D, E, F side, plus the added 15 amperes required to make up the 25 ampere arc, or a total of 45 amperes, so that we have, under that condition, 30 amperes on the A, B, C side outside wire, and 45 amperes on the D, E, F side outside wire and 15 amperes flowing *out* from the dynamo on the neutral. Therefore our 60 ampere fuse would, as a matter of fact, still be altogether too large to properly protect the apparatus. It would require a 40 ampere arc to work fuse 3 to capacity. To be fused absolutely right under those conditions we should have a 30 ampere fuse on one outside wire, a 45 ampere fuse on the other and a 15 ampere fuse on the neutral, but this, of course, is never done in actual practice, since the load carried by fuse 2 would vary with every lamp or motor shut off on either side, and the apparatus is supposed to be protected by its individual circuit fuses.

Note: Now don't start trying to tear this to pieces on technicalities. It is *understandableness* I am after, rather than strictly technical correctness.

If your theatre is fed by a three-wire system you should see to it that the two sides are as nearly as possible balanced. If they were perfectly balanced your neutral fuse could blow without affecting the lights in your house, but if the neutral

fuse blows and the system is unbalanced then the effect is that of forcing the lights on one side above candle power while those on the other side will burn below candle power.

FIGURING WIRE SIZES

To figure wire sizes for three-wire circuits you should proceed the same as for ordinary two-wire systems (page 55), considering only the two outside wires and the amperage necessary to operate the apparatus at 220 volts; then, having determined the size of the two outside wires, make the center wire the same size.

Go to your work each day as though it were your first day on a new job and you had to make good.

Switches

THERE are a few points of importance concerning switches to which the operator's attention should be forcefully directed. I emphasize the "forcefully" because I have seen these things neglected, with consequent heating and even burning at the switch contacts, in all too many operating rooms.

In Fig. 13 we see, at the left, an ordinary single-pole, single-throw knife switch, in which A is the blade of the switch, B the handle, C the contact, D the hinge, E-E the terminals to which the wires are attached, and F the insulating base, which may be slate, porcelain, marble or any other high grade insulating material suitable for the purpose. At the right is a single-pole switch with a second contact, so that

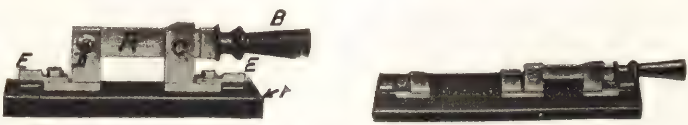


Figure 13.

blade A may be thrown over to make a contact on the other side. Instead of being a single-pole, *single-throw* switch it thus becomes a single-pole *double-throw* switch, or, as ordinarily expressed, a S. P. D. T. switch.

If a switch has two blades, connected by a cross bar of insulating material to which the handle is attached, as per A, Fig. 14, then it is a "double-pole" instead of a single-pole switch. If it has three blades, as per B, Fig. 14, it would be a "triple-pole" or "three-pole" switch, and so on. C, Fig. 14, shows a double-pole single-throw (D. P. S. T.) switch equipped with contacts for knife-blade cartridge fuses, such as are shown at B, Fig. 22; D shows a double-pole single-throw switch with ferrule contacts for cartridge fuses. Switches with contacts for link fuses may be had instead of for cartridge or plug, and may be used for projection circuits, if such circuits are to be protected by link fuses, thus

obviating the necessity for a separate fuse block; E and F show types of porcelain base single-throw, double-pole switches with plug fuse receptacles. These switches are called "panel cut-outs," and may be used to control individual circuits of low amperage.

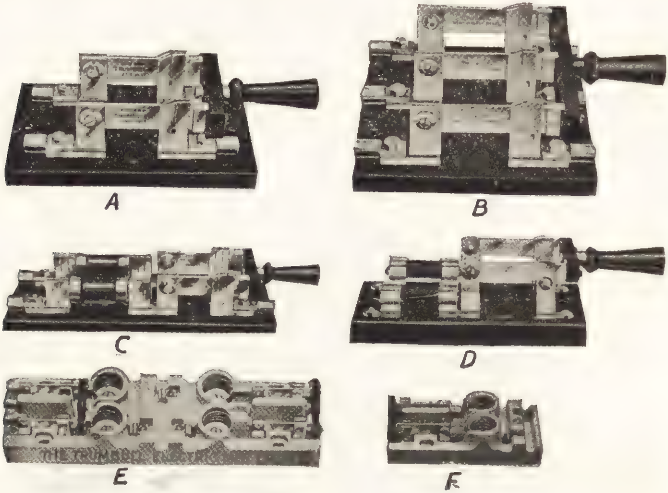


Figure 14.

Inclosed Switches.—An inclosed switch is one with an individual covering, usually of sheet metal, which entirely incloses the switch-blades, contacts, etc. This is the type used for the projection machine table switch. The covering is to protect the operator from accidental contact with live parts of the switch, and to prevent accidental short circuits. With inclosed switches it is important the covering be so made that it cannot come into contact with the live parts of the switch, since if both blades or two contacts of opposite polarity come into contact with the metal, a direct short circuit is formed.

In connecting inclosed switches it is very much better that the blade end of the switch be dead when the switch is open. In fact, that rule applies to all switches, though sometimes circumstances prevent its being adhered to.

Proper Location of Switches.—This is a difficult matter to deal with intelligently, since local conditions must very

largely govern. In general, however, it may be said that the house switchboard should be so located that the man in charge will have an unobstructed view of the screen when at the switchboard. This is of particular importance, since otherwise it will be found very difficult properly to handle the lights at the beginning and end of the show, or at the beginning or end of individual reels.

Switches governing emergency lights (exit lights and all lights kept burning during the performance) should under no circumstances be placed on the main switchboard. You can never tell what an excited man will do, and in case of fire, people inside the auditorium, including employes, are usually excited.

Place the emergency light switches in the box office where nobody can get at them but the ticket seller, and make him or her directly responsible for their proper handling.

In the operating room local conditions will govern the placing of the switches, but it may be said in general there is nothing to be gained by making things inconvenient for the operator, and wrongly located switches often cause much entirely unnecessary labor and annoyance.

The operating room incandescent lights should be governed by one switch, located where it can easily be reached from operating position at either machine. There should also be individual snap switches on each lamp socket.

This is of much importance, because it is utterly impractical, not to say impossible, to have high class projection with incandescent lights burning in the operating room, and the operator is much more likely to extinguish his lights if there is a switch handily located with which he can put them all out at one operation than he is to put out two or three lights by means of their individual socket switches. This is one of the seemingly simple points which is of great importance in its bearing on results on the screen.

NEVER install a knife switch in such way that its handle moves upward in opening the switch.

If it be a single-throw switch, install it so the handle hangs down when the switch is open. If it be a double-throw switch install it so the handle swings sideways. This obviates the danger of the switch accidentally falling shut.

Uses of Types of Switches.—The use of the single-pole switch except for certain purposes is prohibited by Underwriters' rules, and none of those purposes exist in theatres, I think, except that the single-pole switch is of use in the

making of certain rheostat connections, as will be explained under another heading.

The double-pole single-throw switch is the type ordinarily used to control incandescent and projection circuits, and, in fact, for practically all theatre circuits, except those controlled by a triple-pole, or by a double-pole, double-throw switch. The triple-pole single-throw switch is used to control three-wire circuits where they enter the theatre, and wherever else the three-wire circuit may extend. The double-pole double-throw switch is used in certain fuse connections, as will be explained under "Fuses." It is also of use for connecting two separate two-wire supply systems, and for projection circuit connections under certain conditions.

Underwriters' Rules require that switches have certain dimensions, according to the voltage and amperage they are to handle. Both the voltage and amperage capacity must be stamped on some part of knife switches.

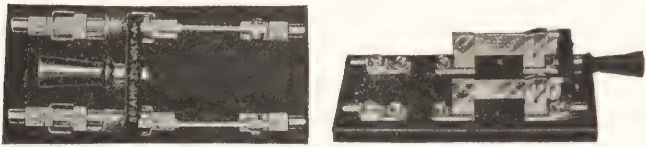


Figure 15.

Fig. 15 illustrates how switches are marked. *Reject any switch not so stamped.* A switch may be used for a less amperage and less voltage than its stamping, but never for higher voltage or amperage. The higher the voltage the farther apart must be the knives of the switch, and the longer they must be. Two hundred and fifty-volt switches are the kind almost universally used in theatres. There is no such thing as a 110-volt switch, the requirements for 110 and 220 being the same.

At the right in Fig. 15 we see an illustration of a switch equipped with fuse link contacts. This is the kind of switch that is used on projection circuits where the circuit is controlled with link fuses.

Care of Switches.—Referring to Fig. 13, hinge D must be kept tight—tight enough so that it requires a slight effort to move the handle. Contacts C must be kept in good condition and must grasp blade A firmly when the switch is closed. If these contacts become loose there will be heating,

loss of power and roughening of both the contacts and the blades, as well as an increase in the resistance of the copper by reason of continuous heating. It is very important that hinge D be kept tight, because otherwise when you close the switch the blade is likely not to strike contacts C squarely and enter quickly, with consequent arcing and burning of the copper. *Use a little common sense and good judgment in dealing with your switches.* Should these contacts become rough by arcing, they may be carefully smoothed with a very fine, thin file, or a piece of 0 or 00 emery cloth wrapped around a thin piece of metal. It is important that the cross bar of the switch be kept tight. A loose, wobbly switch is an abomination, and conclusive evidence of a careless, sloppy workman.

Metal Cabinet.—All operating room switches and others, except the stage switchboard, should be inclosed in a metal cabinet, Fig. 19, Page 72, equipped with a door which automatically closes either by power of the springs or action of gravity. It is a good plan to examine the switches, say, once a week, tightening all loose joints and cleaning off all dust. This may best be done either with a bellows or brush.

Switchboards

IT is essential that both the theatre manager and operator have a very good understanding of the main switchboard. In many of the larger houses the main switchboard is a large, imposing arrangement, which looks very formidable. As a matter of fact, however, these boards are quite simple and easily understood, if one examine them closely, keeping in mind his knowledge of electrical action. On Page 10 of the "National Electric Code," a copy of which may be secured free by sending stamped, self-addressed envelope to the National Board of Underwriters' office, William Street, New York City, appear the following rules, which must be strictly observed in the installation of switchboards:

a. Must be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Switchboards must not be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board. The space back of the board must be kept clear of rubbish and not used for storage purposes.

b. Must be made of non-combustible material.

c. Must be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

If the wiring is on the back, there must be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall.

d. Must be kept free from moisture.

e. Wires with inflammable outer braiding, when brought close together, as in the rear of switchboards, must, when required, be each surrounded with a tight, non-combustible outer cover.

Flame proofing must be stripped back on all cables a sufficient amount to give the necessary insulation distances for the voltage of the circuit on which the cable is used.

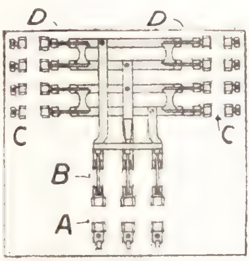
The proper location of the main house switchboard will depend entirely upon local conditions, and may only be properly determined by considering each individual case. The location which will be suitable in one theatre might not be so in another. In fixing the location the manager should be guided largely by the items "accessibility" and "convenience," but *it is essential that the board be so located that the man handling it will have a good view of the screen or of the stage when at his post of duty.* This latter is very essential to the best manipulation of the lights, particularly if there be vaudeville.

In some theatres the house switchboard is located in the operating room, but this I do not consider as being the best practice. The house switchboard should be located below, but a portion of the auditorium lights should be so arranged that they may be handled from both the main switchboard and from the operating room. An emergency may at any time arise in which it is imperative that the auditorium be lighted instantly, as for instance, in case of fire. This can, of course, be done by the switchboard tender below, but there would probably be more or less delay in the response, and, moreover, the signal bell might "go wrong" just at that time. I do not, however, favor the placing of the main board in the operating room under any conditions.

Except there be good reasons for not doing so, every circuit in the theatre, including the operating room and stage feeders, but excepting the emergency lights (emergency lights are the exit lights and those ordinarily left burning during the performance, such as foyer, hall-way and side lights), should pass through the main house switchboard.

On the main house switchboard should be (a) the main fuses, located ahead (on the street side) of everything, except the exit and emergency lights, and carrying the entire house load; (b) the main switch, which kills everything but the exit and emergency lights; (c) fuses for every individual circuit in the house, including the operating room and stage

feeders; (d) service switches for every individual circuit, except the operating room and stage feeders; (e) a switch governing all auditorium circuits ordinarily extinguished during the performance, except where the auditorium lights are handled from the stage. This latter clause, however, may be considerably modified by the peculiarities of requirement in individual installation. In small, strictly moving picture houses, it is much better to have the auditorium lights extinguished all at one time, rather than by pulling half a dozen small switches. In large houses, however, where there are many incandescent lights and circuits, this is not a practical thing to do, and a dimmer should be used.



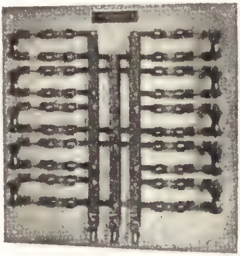


Figure 16.

In Fig. 16 is seen both a diagrammatic and photographic representation of a small three-wire switchboard, or "panel" board. In the diagram, A is the fuse contact, B the main switch, C-C the house circuit fuse contacts, and D-D the service switches on the individual incandescent circuits, all of which are seen photographically represented at the right, excepting that the main switch and fuses are omitted. Both in the diagram and photograph you will take note of the screw heads connecting feeder bars to the circuit bars. This is the secret of the whole thing. The left hand bar of the diagram crosses three bars and attaches to the fourth; the center bar crosses one bar and attaches to the two center bars, and the right hand bar attaches to the lower cross bar. Now the application of a little horse sense to this will show you that the two top cross bars take current from the left hand outside feeder, or "bus bar," and the neutral, which forms a two-wire circuit leading both ways from the connection. The

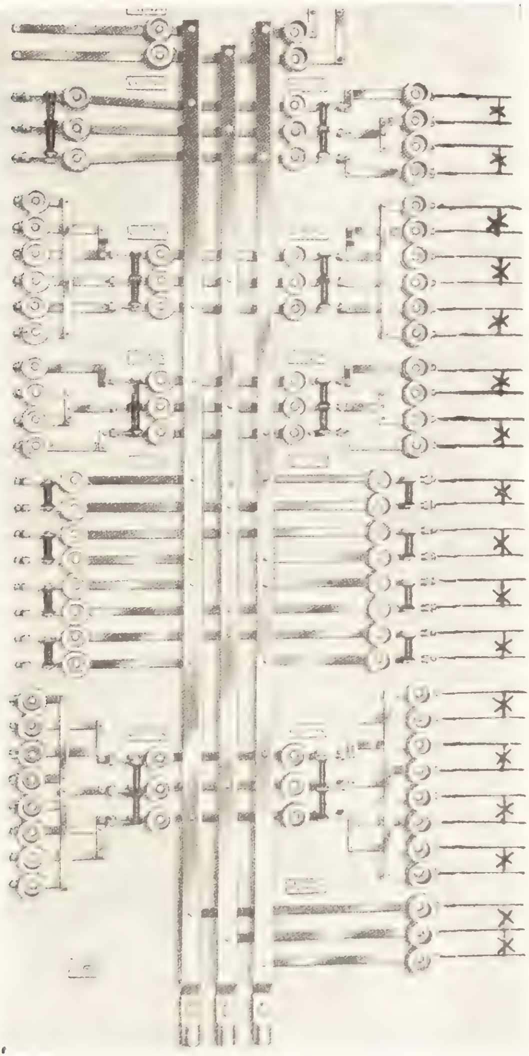


Figure 17.

two lower cross bars attach to the right hand outside feeder, or "bus bar," and the neutral, which forms another circuit, on "the other side" of the system, leading both ways from the contact.

In examining any switchboard, just look at the contacts, or the screw heads, for they will show you how the whole thing is connected. It is very easy, after you have a little practice, but it is a mighty puzzling thing to the beginner.

Fig. 17 is the representation of a large, somewhat complicated board. On one side the individual circuits are indicated. Study the contacts and you will be able to trace out the connections. Taking the top right hand switch, for example, we find the circuit starts off as a three-wire circuit, through fuses and a triple-pole switch, which latter controls the circuits. It then splits into two two-wire circuits, each having their own fuses, because fuses must always be established on individual circuits, or where wire sizes change. The lower wire of the upper two-wire circuit and the upper wire of the lower two-wire circuit attach to the neutral, and the upper wire of the upper and the lower wire of the lower two-wire circuit to the outside wires of the three-wire circuit. Remembering that the neutral is positive to one outside wire, and negative to the other, we instantly see that the two upper and two lower wires are mates, that is to say, they are pairs, forming two two-wire (multiple arc) circuits. We also see that we cannot extinguish the lights on one circuit without extinguishing the lights on the other, except that we remove the fuses on one of the circuits, this latter by reason of absence of individual circuit service switches.

Just below the center of the board is a bank of circuits tapped off as two-wire circuits right at the bus bars. By observing the location of the screw heads we see which side each circuit connects to. We see there are four screw heads in each outside bus bar in this bank of two-wire circuits, therefore there are four circuits on either side, and these circuits, provided each carries appliances using the same total amperage, is said to be "balanced." At the bottom we see a three-wire lead with fuses, but without switch. This is probably the stage or operating room lead, which should not have a switch on the main house board. The main switch and fuses controlling and protecting the entire board are not shown.

In the smaller theatres it is common practice to build up a switchboard out of porcelain-base panel cutouts, such as is

illustrated in Fig. 18. Any number of blocks may be used. They must be placed in a substantial metal cabinet, similar to the one shown in Fig. 19. Back of the blocks should be a

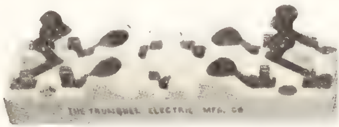


Figure 18.

layer of sheet asbestos, or asbestos millboard, not less than three-eighths of an inch thick. If properly put together such a board is just as efficient, though it does not look as well, as the regular board built on a slate base. Ahead of a board of this kind should be the main switch, and a cutout block carrying the main fuses.

Exit and Emergency Light Boards.—The feeders for these circuits must be tapped to the main feeders on the street side off the main house fuses.

They must be controlled by switches located in the box office, and by no other switches.

For further information concerning this subject see Fig. 28, Pages 85 and 86.

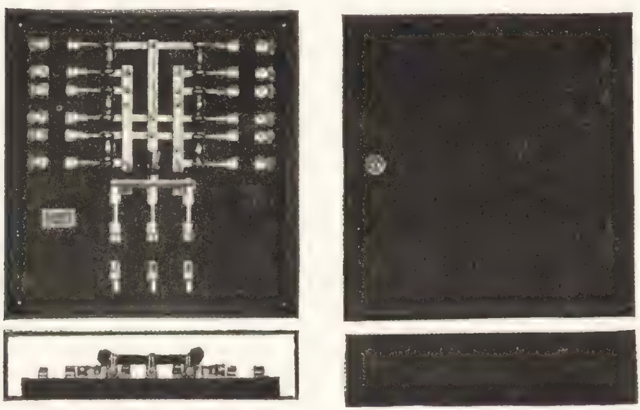


Figure 19.

Illustrating small panel boxes and switchboards.

Stage Switchboard.—The stage switchboard should be located on the proscenium wall. It is common practice to place it to the right of the stage as one looks toward the audience. It should be protected by a substantially constructed iron railing, not less than 48 inches high and located not less than 36 inches from the face of the board, and to be securely fastened to the floor in such manner as to withstand a heavy shock, as, for instance, a person falling violently against it, or scenery falling on it.

All fuses on a stage switchboard must be approved cartridge or plug type. It is absolutely forbidden, under any circumstances, to use a link or open fuse on the stage.

The stage switchboard should carry (a) main fuses and main switch supplying all stage circuits; (b) service fuses and switches for each individual circuit, plainly labeled with name of circuit it controls, thus: "White Foots," "Red Foots," "First Borders, White," "First Borders, Green," etc.

Stage switchboards need not be equipped with a cabinet and door, but every precaution must be observed to render accidental contact with scenery impossible. The utmost care must be exercised that all switch contacts and wire contacts and fuse contacts be kept tight and in perfect electrical and mechanical condition, to prevent any possibility of heating. The wires should be thoroughly examined at regular intervals to see that the installation is in perfect condition. In fact, inasmuch as there is always more or less (usually more, and sometimes a great deal more) inflammable material constantly exposed on the stage, it is impossible to be too care-

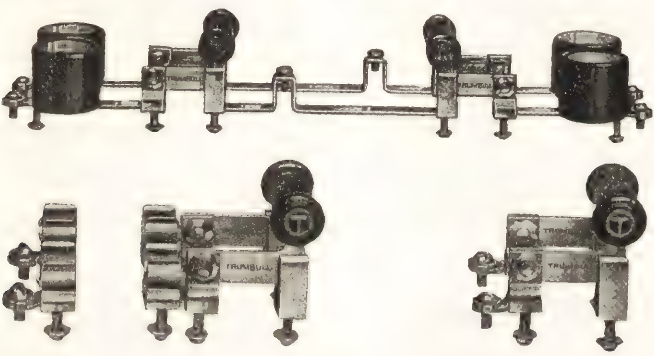


Figure 20.

ful with the electrical installation and in assuring its maintenance in perfect condition.

Absolutely no one except the man in charge of the stage switchboard should be allowed to touch it while a performance is under way, and the fewer persons handling it at other times the better. Stage switchboards should always be wired from the back. This is not absolutely necessary, but it looks better and *is* better. This also is true of the main house switchboard. It is not necessary that an expensive marble board be purchased.

Fixtures such as those illustrated in Fig. 20 may be had from any dealer in electrical supplies. You may then purchase a marble or slate slab of your local dealer, first having ascertained the length of the fixture bolts so that a slab of proper thickness may be selected. Having secured such a slab, any man of ordinary intelligence can lay out and drill the holes. Affixing the fixtures to the slab is then merely a matter of placing the bolts in the holes and tightening the nuts.

For a small board, one-half inch asbestos millboard makes a fairly good support. If it is a main house switchboard the sides of such a board must afterward be covered with a metal rim to receive a metal door. If rightly done such a board will not be excessive in cost and will look very much better than a board built up of blocks as per Fig. 18.

First lay out the board on paper, just as you want it, locating all the holes carefully, then lay the paper on the marble, slate, or whatever base you use, mark the holes, and drill them. Manufacturers will, upon request, supply you with a catalog giving the dimensions of fixtures such as are shown in Fig. 20.

A general idea of the layout of a small moving picture theatre switchboard is had from Fig. 21, in which X-X-X-X, etc., are circuit switches, carrying fuses, and Y and Z fuses and switches on the stage and operating room circuits.

A small gas plier is the handiest tool with which to remove and insert cartridge fuses. Wrap the handles of the pliers with insulating tape to avoid possibility of shock.

If a fuse blows and you are not certain which one it is touch your test lamp terminals to the fuse terminals *before moving either fuse* and without opening the switch. If the lamp lights that's the fuse. If it doesn't then it is the other fuse. If it lights on neither then either both fuses are blown or the circuit is open somewhere. To make this test on projection circuit fuses the carbon must be frozen.

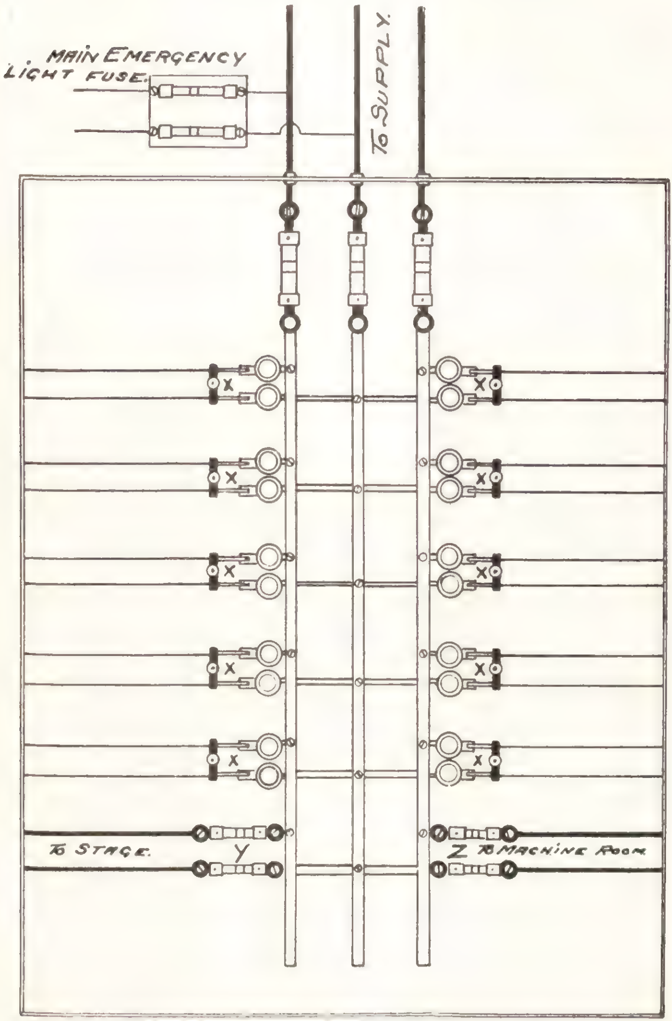

MAIN EMERGENCY
LIGHT FUSE.
TO SUPPLY.
X
TO STAGE.
Y
Z TO MACHINE ROOM

Figure 21.

Fuses

AS has already been set forth, an electric conductor will only carry a certain given number of amperes of current without developing heat. See Table 1, Page 42. Ordinarily only the quantity of current consumed by the motors and lamps attached to the circuit will flow over the wires of the circuit, and the capacity of the lamps and motors is never presumed to exceed the rated capacity of the wires. However, many things, such as grounds, short circuits, or a rise in the voltage may occur to cause a rush of current sufficient to overload the wires, or, in the case of rise in voltage, overload the apparatus attached thereto, and possibly the wires as well. The fuse is a sort of automatic safety valve designed to take care of just this sort of thing.

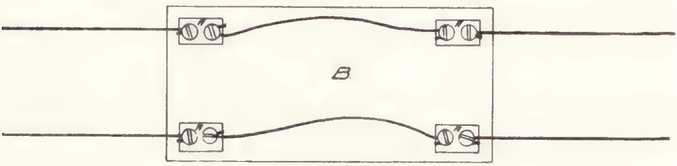
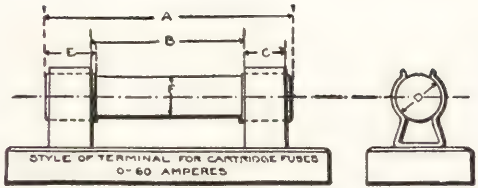


Figure 22.

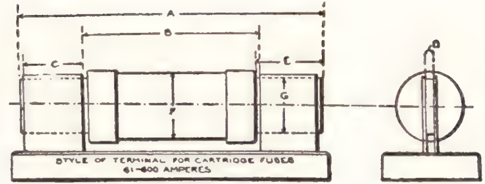
In Fig. 22 we see the principle of the fuse illustrated. The wires of the circuit are cut and their ends attached to terminals A-A-A-A fastened to slate base B. Under these terminals are clamped two pieces of fuse wire composed of an alloy of metals having very low melting temperature and a high temperature coefficient, which means that their resistance rises very rapidly with increased temperature. The operation is as follows: The current capacity of the fuse wires is in no case presumed to exceed the rated capacity of the wires of the circuit they protect (See Table 1) and to only exceed the combined current consuming capacity of the lamps attached to the circuit by a small margin, and to only exceed the combined current consuming capacity of the motors by 25 per cent.

Assuming, for example, a circuit the wires of which are rated at 6 amperes R.C., and that a sufficient number of incandescent lamps are attached to consume a total of 5 amperes, we would insert a 5-ampere capacity fuse wire between the terminals of our block, Fig. 22. Such fuses would actually carry a little more than 5 amperes, because fuses are designed

TABLE No. 4



Form 1. CARTRIDGE FUSE—Ferrule Contact.



Form 2. CARTRIDGE FUSE—Knife Blade Contact.

Voltage.	Rated Capacity. Amperes.		A Length Over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.	D Diameter of Ferrules or Thickness of Terminal Blades. Inches.	E Min. Length of Ferrules or of Terminal Blades outside of Tube. Inches.	F Dia. of Tube. Inches	G Width of Terminal Blades. Inches.		Rated Capacity. Amperes.
Not over 250	0-30 31-60	Form 1	2 3	1 1¾	½ ⅝	9/16 13/16	½ ⅝	½ ¾		Form 1	0-30 31-60
	61-100 101-200 201-400 401-600	Form 2	5⅞ 7⅛ 8⅝ 10⅜	4 4½ 5 6	⅞ 1¼ 1¾ 2⅛	⅛ 13/16 ¼ ¼	1 1⅜ 1⅞ 2¼	1 1½ 2 2½	¾ 1⅛ 1⅝ 2	Form 2	61-100 101-200 201-400 401-600
Not over 600	0-30 31-60	Form 1	5 5½	4 4¼	½ ⅝	13/16 1 1/16	½ ⅝	¾ 1		Form 1	0-30 31-60
	61-100 101-200 201-400	F'm 2	7⅞ 9⅝ 11⅝	6 7 8	⅞ 1¼ 1¾	⅛ 3/16 ¼	1 1⅜ 1⅞	1¼ 1¾ 2½	¾ 1⅛ 1⅝	F'm 2	61-100 101-200 201-400

to carry a 10 per cent. overload in excess of their rated capacity, in order to allow for ordinary fluctuations in voltage. Now suppose a short circuit or ground occurred somewhere on the circuit, which would cause a rush of current and overload the wires, or suppose there is a heavy rise in the voltage, which would have the effect of forcing more current through the resistance of the lamps, thus overloading the wires, with possibility of results more or less disastrous. What happens? Why, just this: The fuse wire is overloaded and becomes hot, whereas no damage would be done to the copper wire until it reached a temperature far in excess of that which would melt the fuse wire, therefore both the wires of the circuit and the lamps are protected by reason of the fact that the fuse wire melts and automatically stops all flow of current, thus "cutting out the circuit." Nor can a new fuse be installed until the trouble has been remedied, since if an attempt be made to install a new fuse without removing the seat of the difficulty it would promptly melt (blow) and again stop the flow of current. That is the theory of the fuse, as well as its practical operation, though raw fuse wire is not employed in theatres, except in the "link" fuses used in some cities to protect projection lamp circuits, the same being located in an iron cabinet in the operating room.

Safety fuses are made in a number of forms, but those with which the moving picture operator comes into contact are known as the "plug" or the "cartridge," both these forms being in general use in theatres.

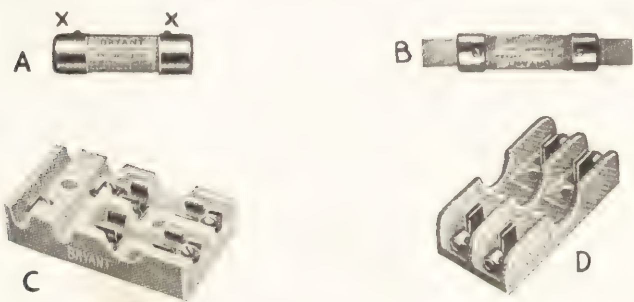


Figure 23.

In Fig. 23, A, B, are cartridge fuses with different styles of terminals, A, the "ferrule" contact, only being allowed on

circuits carrying 60 amperes or less. C and D are receptacles for A and B. B is the "knife-blade" contact fuse.

Cartridge Fuses.—A cartridge fuse consists of two metal terminals joined by a paper barrel. Inside this barrel is the fuse wire, connecting the two terminals, with a small pilot wire passing under the round spot on the paper label, as is illustrated in Fig. 24. An air chamber is used in some fuses, the idea being that the heat conduction through the confined

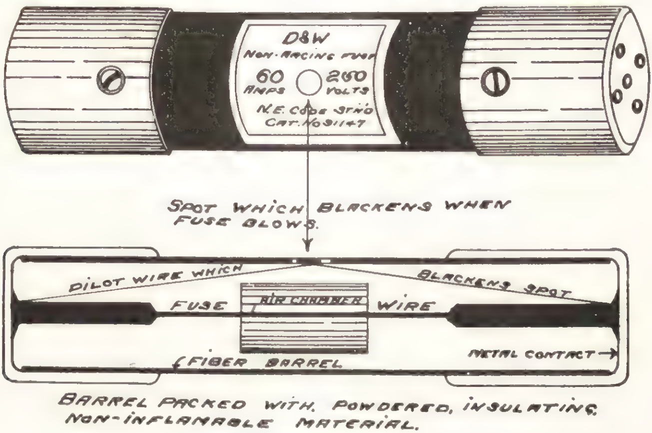


Figure 24.

air being slow, the temperature in that part of the fuse will rise rapidly and always in the same ratio, thus establishing a practically constant point of blowing.

The fuse wire is surrounded by a powdered, non-conducting substance designed to instantly break the arc when the fuse blows. On the paper label on the outside of the barrel is a small round spot, under which the pilot wire passes. When the fuse blows the pilot wire is supposed to melt and turn the spot black, but it doesn't always do it.

Table 4 gives an idea of the essential points in a cartridge fuse. The Underwriters require that the contacts have a certain area, that the paper barrels have a certain length and diameter, and that the fuses have a certain length over all for a given voltage and amperage. Table 4 is taken bodily from the "National Electric Code."

PLUG FUSES

The plug fuse, A, Fig. 25, consists of a porcelain base with a brass screw, and a center contact at its lower end, with a protecting brass cap at its upper end, the latter usually having a clear mica center so that you can look through and see if the fuse wire is intact. Ordinarily, however, you cannot do anything of the kind with any degree of certainty, any more than you can depend with certainty on the spot of the cartridge fuse turning black when the fuse blows. *The only way*

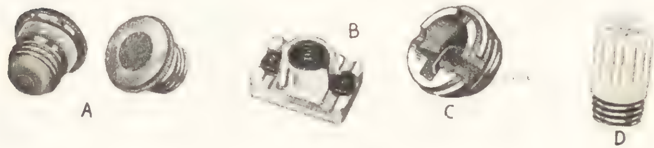


Figure 25.

is to test a fuse in the manner set forth further on. B, Fig. 25, shows the receptacle for plug fuse A, and C a fuse with the cap off, showing fuse wire. D is a special form of plug fuse to be used with amperage between 35 and 60. Plug fuses, in their regular form, A, Fig. 25, are not made in excess of 35 amperes capacity. They are not made in any form for capacity in excess of 60 amperes. Plug fuses may be used for any kind of work up to the limit of their capacity. They are perfectly safe, and somewhat cheaper than the cartridge fuse.

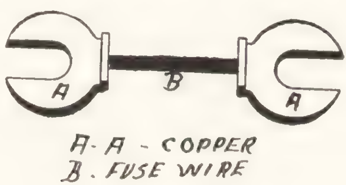


Figure 26.

LINK FUSES

The link fuse, Fig. 26, provided its receptacle be placed inside a metal box having a metal cover, is perhaps the best fuse to use for the projection circuit: this for several reasons, not the least important of which is the fact that it cannot

readily be "boosted" without the trick being plainly visible to the inspector. In other words, the link fuse is very largely fool-proof. With both the plug and cartridge fuses it is quite possible for operators possessed of more cunning than good sense to increase the capacity of their fuses almost indefinitely by placing a short piece of copper wire, or sheet copper, called a "jumper" in the terminals in such manner that it is under the fuse, hence out of sight. Such a trick could only be detected by close inspection, which is not true of the link fuse. The plug fuse may be boosted after the same fashion by placing a copper penny inside the receptacle and screwing the plug down on it in such manner that the two contacts are connected by the copper. Such tricks as this, however, render the fuse of no value, and *leave the circuit to all intents and purposes entirely unprotected. They cannot be too strongly condemned,* and *any operator or other person caught boosting fuses ought to be instantly discharged and have his license, if he have one, revoked.* By reason of the difficulty in boosting a link fuse the Department of Water Supply, Gas and Electricity of the City of New York has issued a rule compelling the use of link fuses on projection circuits where the current used exceeds the capacity of the ordinary plug fuse, viz., 35 amperes. Both fuse blocks and switches may be had to carry link fuses. (See Fig. 15.)

Never fuse above the rated capacity of the wires of the circuit. Never fuse an incandescent lamp circuit above the combined amperage capacity of its lamps. Never fuse a motor circuit above the rated capacity of the wires, or more than 25 per cent. above the rated capacity of the motor or motors.

Underwriters' rules allow the fusing of the motor circuit to 25 per cent. above the capacity of the motor, or the combined capacities of two or more motors, provided, of course, the wires are large enough.

It is physically possible to refill both the cartridge and plug fuse, but *it does not pay to do so.* The only safe rule is:

Throw all blown fuses away. *There will then be no mixing with the good ones, with consequent vexatious delays.* If you mix your good fuses with bad ones you are more than apt to have such delays, which may and probably will happen just at the very worst possible time, and be chargeable entirely to your own carelessness.

PROJECTION CIRCUIT FUSES

The projection circuit offers nothing in any way susceptible to damage through momentary overload. It is a nuisance to

have fuses constantly blowing, and, since the resistance of the hand-fed arc lamp is a variable quantity, current flow will under any condition vary considerably. I would therefore recommend for projection circuits the following, with the understanding that the current flow at the arc is what is referred to under the heading "Normal Amperage." Of course, if the fusing is only done on the primary of a transformer (economizer, compensarc, inductor, etc.) then due allowance must be made.

TABLE NO. 5.

Operating room fuse capacity where rheostats are used for resistance.

Normal Arc Amperage	Fuse to	Necessary size R.C. portion of circuit wires	Necessary size asbestos covered portion of circuit wires
20	25	6	6
25	30	6	6
30	35	6	6
35	45	6	6
40	55	5	6
45	60	4	6
50	75	3	5
55	80	3	5
60	85	2	5

Explanation of Table 5: Wires must be large enough to accommodate the *fuse capacity* without overload. That portion of the circuit which is asbestos-covered wire may be treated as weather-proof in this respect.

FUSING FOR MOTOR GENERATOR OR ROTARY CONVERTER

This is a simple matter. Ordinarily there are fuses both on the intake and output lines—on the motor and generator side. Ascertain the amperage at your arc under normal conditions, and add about 20 per cent. of that amount, which will give the size for your fuses on the generator or output side. The arc will, of course, be D. C., hence 48 volts. Therefore the arc amperage multiplied by 48 will give the arc wattage, which, divided by the intake (line) voltage, will give the intake amperage, or would give it if the machine had 100 per cent. efficiency. Few machines, however, have more than 65 per cent. efficiency; therefore to this must be added 35 per cent. in order to get the actual intake in amperage, thus: Assuming a line voltage of 110 and an arc wattage of 1920, then 1920 watts $\div$ 110 volts $= 17\frac{1}{2}$ amperes, and 35 per cent. of $17\frac{1}{2}$ amperes is $6\frac{1}{2}$ amperes and $17\frac{1}{2} + 6\frac{1}{2} = 24$, therefore the intake amperage, based on the assumption that the

machine has 65 per cent. efficiency, is 24, but we will install 30 ampere fuses, since the Underwriters approve of fusing a motor 25 per cent. above its actual capacity.

The following must be qualified, however, by the fact that if the generator is of higher voltage than the arc, then the arc amperage must be multiplied by the voltage of the generator instead of the voltage of the arc, since resistance will have to be used to cut down the voltage to 48, and voltage wasted in resistance counts just the same as that used in operating the arc.

Plenty of fuses should be kept on hand. You never can tell when one will blow, and sometimes a sort of epidemic of fuse blowing occurs. It is very awkward to get caught without fuses, and the only insurance against it is a good surplus stock, but be very careful that blown fuses don't get mixed with the good ones.

In case you do get caught without fuses you can protect the circuit temporarily with one fuse, bridging the two other fuse terminals with copper wire. *This is by no means a good condition, and may only be tolerated temporarily,* in case of emergency, until the proper fuses can be procured. Such a condition would, in fact, be very bad, and emergencies of this kind never ought to occur. It is possible to make a fuse of copper wire, and while such a fuse would be to a considerable extent unreliable, and from every point of view objectionable, stili it may be used *temporarily* in an emergency, therefore I give the fusing point of small copper wires.

TABLE NO. 6.

Fusing Point of Copper Wires.

American (B. & S.) Wire Gauge	Fusing Current in Amperes
30	10
28	15
26	20
25	25
24	30
22	40
21	50
20	60
19	70
18	80
17	100
16	120
15	140
14	160
13	200

By adding two copper wires of different sizes together, fuses of almost any desired strength may be had, thus: A No. 30 and 17 wire combined would make a 47 ampere fuse.

IN CASE OF TROUBLE

Should a fuse blow and upon installing a new one it also immediately blows, it is conclusive proof there is heavy overload, most likely due to a heavy short or ground, and the circuit must be left dead until the trouble is remedied. You will most likely find the difficulty exists in the form of a ground, or a short caused by something of current carrying capacity connecting the wires at some exposed point. A ground, will, however, be the most likely cause of the trouble. (See Testing for Grounds.)

A rise in voltage will operate to force more current through the lamps and motors, thus causing an increase in the amperage, which may blow the fuses. It will be evidenced by the incandescent lamps burning above c.p. Should a fuse blow and the new one installed also blow after a few minutes, or an extended time, first of all examine the fuse contacts, as loose or dirty contacts will generate heat which may be sufficient to cause the trouble.

Fuses will sometimes blow and it will be difficult to tell which one of the two it is. I would recommend the installation at some convenient point to the main switchboard of a fuse tester made as per Fig. 27.

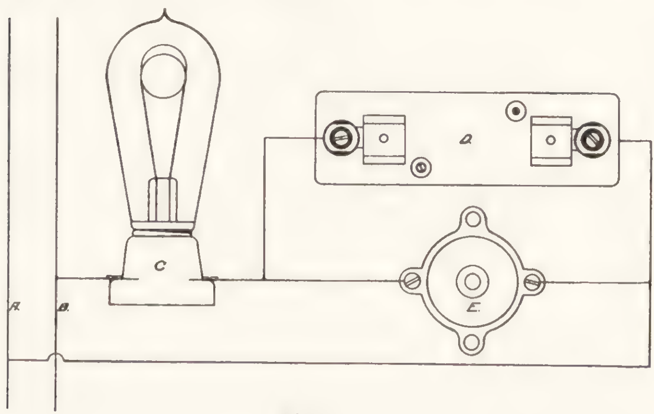


Figure 27.

A and B, Fig. 27, are wires of any circuit that is always "alive," preferably the main theatre feeders ahead of the switchboard fuses. If you attach at that point and the house is fed by a three-wire system, be sure to attach to one outside wire and the central or neutral wire, else you will have 220 volts on your tester; D is an ordinary cartridge receptacle; E a plug fuse receptacle; C an incandescent lamp of the voltage of your current. When you put a fuse in either of the receptacles and lamp C does not light the fuse is worthless and should be thrown away.

Cartridge fuse voltage and amperage rating are usually found on a paper label on their barrel; the plug fuses have their rating stamped on the brass cap, and link fuses have or should have their rating stamped on one of the copper contacts at their ends.

Fuses are Ordinarily Installed as Follows: (a) Main service fuses, located ahead (on the street side) of the main switch. These fuses carry the entire load of the theatre, except the exit and other lights ordinarily left burning during the performance. Circuits carrying these latter, called emergency lights, should be attached to the feed wires ahead (on the street side) of everything else, and have service fuses of their own (see Page 86). In some houses the stage is fed by a separate set of feeders coming from the street mains, in which case these circuits will, of course, have main fuses of their own. (b) Fuses, usually on the main house switchboard, carrying the operating room feeder circuit. (c) Fuses, on the main switchboard, carrying feed wires for the stage, if the stage takes its current through the main switchboard, as is usually the case. (d) Main fuses in the operating room, which carry all operating room circuits. Also individual service fuses in each separate projection machine line and operating room motor and incandescent circuit. (e) Fuses, ordinarily located on the main house switchboard, on each individual incandescent circuit. (f) Fuses on the stage switchboard for each individual circuit, as well as main fuses carrying all circuits except exit and emergency light circuits. (g) Fuses, usually located in the box office, carrying the entire emergency light system, as well as fuses for each individual emergency light circuit. (h) Fuses for each individual emergency light, particularly in the case of exit lights. (i) Fuses *must* be installed wherever a change in size (diameter) of wire occurs.

FUSING EMERGENCY LIGHT CIRCUITS

Main fuses for emergency light circuits should not be located on the house switchboard, but should be in the box office. In addition to this, every separate circuit must have fuses of its own, and, still in addition to this, it is an excellent scheme to fuse each individual emergency light, especially the exit sign lamps, with 1 ampere fuses of its own, then if trouble should develop in a lamp, it will simply blow its own fuse *without disturbing the other emergency lights, whereas* otherwise it would, or at least might put out of commission the whole circuit, or possibly even the entire emergency light system.

Every circuit, no matter how large or how small it may be, must be protected by its own individual fuses, in addition to the main fuses carrying all circuits.

Plug or cartridge fuses are the only types it is permissible to use in a theatre, except that, unless local law prevents, link fuses inclosed in metal cabinet may be used in operating rooms for projection circuits.

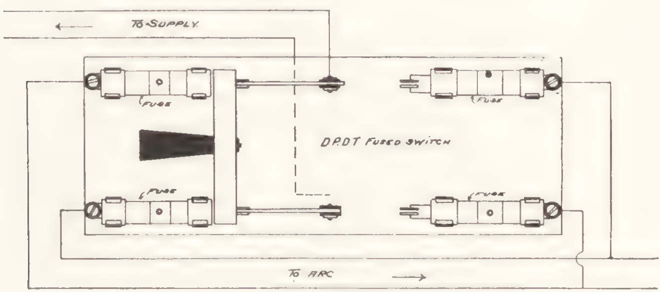


Figure 28.

The blowing of projection circuit fuses is a very annoying thing, since it stops the show and causes delay while new ones are installed. It does not necessarily follow there is anything wrong because a projection circuit fuse blows, particularly if the circuit is not fused much above the amperage being used. By installing two sets of projection circuit fuses, as per Fig. 28, delays of this kind are avoided, because one only has to throw over the switch to cut a new set of fuses, and unless there be something wrong with the circuit there is no appreciable delay.

LAMPHOUSE AND RHEOSTAT WIRE TERMINALS

Both the lamphouse and rheostat terminals are subjected to considerable heat, therefore it is not practical to solder the lugs to the wire. There are a number of fairly good terminals made for use under such conditions, but those made to connect with the wire by bending over and squeezing down a set of copper lips, D-D-D, Fig. 29, are, as a general proposition, too light for use with the modern high amperage. The best non-solder terminals are those made of brass, or some composition metal, which have ample cross-section, and which clamp the wire either by tightening down on screws or by screwing up a section of the terminal. Among the best of these are those illustrated at A-A-A, B-C-C-C and E-E, Fig. 29, A-A-A and E-E being identical, except for the hook connection on the former.

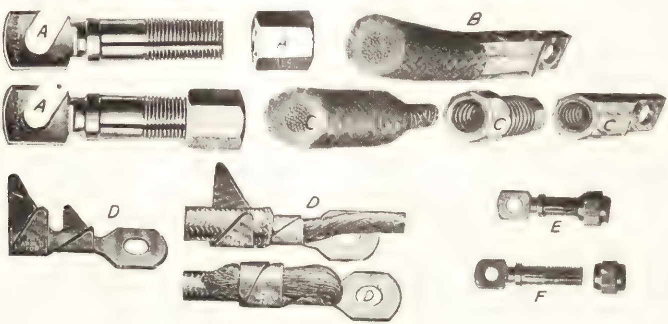


Figure 29.

There are many other good lugs, these illustrated being merely examples.

It is particularly necessary that the binding posts and terminals of the rheostat and arc lamp be kept perfectly clean, and, by reason of the fact that metal is likely to oxidize under the action of heat, both the rheostat and arc lamp connections should be taken apart about once a week and thoroughly cleaned, either by sandpapering or scraping. The operator should not neglect things of this kind. He may think they are of minor importance, but in that he is mistaken. It not only costs actual money through waste of power, but, also, by decreasing the arc amperage, injures the illumination of the screen.

Wire Terminals

EVERY wire ought to have a terminal lug, and, except in cases where the same will be subjected to heat, as, for instance, in a lamphouse or on a rheostat, these lugs should be soldered to the wire. They come in a number of forms, but almost any of them will serve the purpose very well if properly attached to the wire. In order to solder a lug to the wire proceed as follows: First measure the depth of socket in the lug, and cut off enough of the insulation of the wire to just let the end of the wire reach the bottom, scraping the bare end of the wire perfectly clean, until it shines. This latter is important, since otherwise the wire cannot make perfect electrical contact with the solder. Next, first having made sure the inside of the wire socket is perfectly clean, hold the lug in the flame of a blow-torch or some other source of heat and melt sufficient solder into it to fill the hole about half full. Don't get the terminal too hot, but just hot enough to make the solder thoroughly liquid. Now, having put a little flux on the bare part of the wire, shove it down into the solder and hold it until it sets.

Caution.—Don't shove the wire into the lug with a quick push. If you do the solder will probably squirt out, and you may get badly burned. Warm the end of the wire and then shove it in firmly, but not too fast. If directions are followed you will have a perfect electrical joint. In attaching terminal lugs to binding posts always be sure that both the lug and binding post are perfectly clean. A little No. 0 sandpaper or emery cloth will be found handy for cleaning contacts; also you can scrape them with a knife blade.. It is, however, exceedingly important that when a copper wire is joined directly to a binding post it be perfectly clean, since ofttimes a thin coating of oxidation will cover the metal, and this coating, while it is almost thin enough to be invisible, offers high resistance. The resistance of one such joint would not amount to very much, but that of a dozen would cost you a good many dollars in wasted energy in the course of the year—remember that your meter registers all energy consumed, whether it be used in overcoming useless resistance or in the production of light and power.

WIRE SPLICES

A wire splice is something every operator should know how to make correctly. An imperfect splice will heat and cause loss of power. It may cause the wire to burn off entirely. In any event it is a constant source of loss of energy through its excessive resistance.

A splice must be electrically perfect, and should in all cases, unless a strictly temporary joint, be soldered.

In Fig. 30 several correct methods of making splices are illustrated. First, the insulation must be removed from the two ends to be joined, for a distance of from two to four inches, according to size of the wire. The insulation should be whittled away just as you whittle a lead pencil. Never cut the insulation square off by running the knife blade around the wire. This makes a very neat looking job, but the trouble is that the blade is likely to cut a slight ring around the wire, and this ring acts very much as a scratch

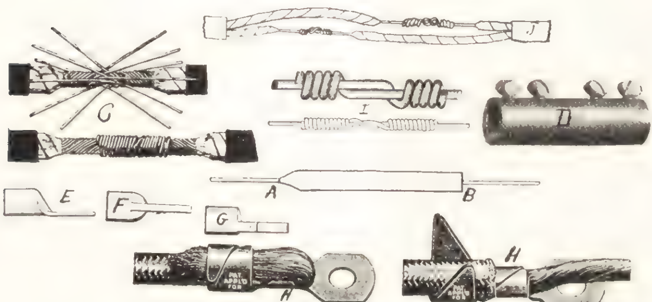


Figure 30.

on the surface of glass does, causing the wire to break very easily at that point. The correct method is shown at A, Fig. 30, and the incorrect at B. What is perhaps the best method of making a splice in asbestos covered, stranded wire is illustrated at C, Fig. 30, except that the strands should be divided into about six sections.

After removing the insulation the wire ends must be thoroughly cleaned, until they shine. This may be done with emery paper, or by scraping with a knife blade. But, however it is done, the wire must be made perfectly clean, else there will not be good electrical contact. The wire ends must

then be twisted tightly together as at 1, Fig. 30, after which the joint must be soldered. Underwriters' rules provide that a wire splice must be made both mechanically and electrically perfect before soldering. After the joint is made, as per Fig. 30, proceed to solder it as follows: Wet it thoroughly with a soldering fluid, or its equivalent, which may be had from electrical dealers in stick form. An excellent soldering fluid is made of

Saturated solution of zinc chloride.........	5 parts.
Alcohol	4 parts.
Glycerine	1 part.

After thoroughly wetting the joint with the fluid, or rubbing on plenty of the flux in stick form, hold the wire in the blaze of a gasoline torch until warm, and then also hold in the blaze a piece of solder, which may be had of electrical dealers in wire form, until it melts and runs all through the joint. Care must be had not to get the wire too hot, ince, especially with the smaller wires, too much heat causes injury and reduces the carrying capacity; also if too hot the solder will run through and out of the joint. If the soldering is properly done the joint will have more mechanical strength and as great carrying capacity as the wire itself. *All joints must be soldered,* except they be strictly temporary, say to use for one day only. After soldering, the splice must be wrapped with insulating tape, to the depth of the original insulation. One or two thicknesses of tape are not enough. If properly done, the use of a wire connector, D, Fig. 30, is permissible; but the soldered joint is best. Wire connectors must not be used for joining asbestos-covered, stranded wires, except the end of the wire be first run full of solder, thus binding the strands together in a solid mass.

For wires connecting to switch, or other cold binding posts, lugs similar to E, F, G, Fig. 30, must be used, but before inserting wire ends into connectors, or lugs, they must be thoroughly cleaned by scraping with a knife blade, or polishing with emery paper. Where such lugs are used, the wire must be soldered into them.

Keep always in mind the fact that unless a wire splice or joint be very carefully made it will heat more or less and cause resistance, which means constant loss as long as the splice or joint is used. The loss from one imperfect splice or joint may be slight, but the combined loss from several may amount to considerable.

Lenses

BROADLY speaking, the function of a lens is to receive upon every portion of its surface light rays emanating from every pinpoint of the surface of a more or less distant object, and to so reflect and direct these rays that the image of the object will be formed, either of equal, less, or greater dimensions than those of the original object, at a distance from the opposite side.

There are many terms used in connection with lenses, but I think that, so far as the operator be concerned, only a few are of real importance.

The Optical Axis of the lens is an imaginary line running exactly through the center of the diameter of the lens, or, in other words, the center of the lens, being precisely at right angles to its plane. Another way of expressing it would be that, understanding that the surface of a lens is always the surface of a segment of a true sphere, a line drawn from the exact center of the circles shown in Fig. 34 through the exact center of either one of the two lenses shown would of necessity be the optical axis of the lens, because it would pass exactly through the center of the lens and be exactly at right angles to its plane.

The Conjugate Foci refers to two points, one being the distance to the lens from a light source or object, and the other to the distance from the lens to the point where the rays from the light source, or object, are refocused into an image. Altering the distance of one of these points from the lens automatically alters the other.

The conjugate foci are shown in Fig. 32, in which the object might be substituted for the image, without changing the general effect. The image would occupy the position now occupied by the object and vice versa. In a projection machine the conjugate foci points of its objective lens are the film at the aperture and the screen. If an actual picture be placed on the screen and brightly illuminated and a piece of ground glass be placed over the machine aperture it would be found that an image of the picture would appear thereon, and if the picture be the size ordinarily projected by the lens at that distance, then the image will just fill the machine aperture.

Refraction.—A lens depends for its action on the fact that light rays traveling through a transparent medium of uniform density will travel in straight lines until they enter, at an angle, a transparent medium of different density, whereupon, at the exact point of entry into the second medium, their direction will be changed and the amount of change will be in proportion to (a) the angle at which the ray enters the second medium and (b) the relative density of the second medium as compared with the first. If the angle at which the rays strike the second medium be slight the bending or refraction will be slight; if the angle be heavy the bending (refraction) will be proportionately greater. If the difference in density of the two mediums be slight the bending (refraction), due to this fact, will be slight; if the difference in density be great, then the bending of the rays will be proportionately greater.

It is somewhat difficult to intelligently explain the reason for the bending of the light ray, nor do I know that from the operator's viewpoint it is necessary. Suffice it to say that light rays *do* bend under the conditions before named; therefore, when light passes from air into glass at an angle or from glass into air at an angle, the ray is bent (refracted) and, as before said, the amount of bending will depend upon the amount of angle and the relative density or refractive index of the glass as compared to that of the surrounding air. The refractive index of glass is equal to the size of the angle made by the incident ray, divided by the size of the angle made by the refracted ray.

In this connection it would be interesting to know whether there would be any actual difference as between the action of a lens used at sea level and one used at, say, the summit of Pike's Peak. Theoretically there would; practically, I doubt it. It is merely an interesting point, based on the fact that the amount of refraction depends partly upon the relative density of the two mediums.

Back Focus.— The "back focus" of a lens (commonly expressed as B. F.) is the distance from the object (film in the case of the projector objective) to the first surface of the lens. This is a very important matter to the operator, since it is practically impossible for him to locate the point of equivalent focus (E. F.) in any given objective with accuracy; also it would be very difficult for the operator to measure the actual distance from the point of E. F. to the film with the lens in actual working position, and, since any given lens may work in a great many different positions (distance from

the film), and these different positions of the objective require special treatment in the matter of the condenser, it is highly important that the operator be able to make precise measurement of the lens position. This is made possible by using the back focus for the purpose, only using the E. F. to figure focal length of lens necessary to project a picture of given size at a given distance.

Equivalent Focus.—"Equivalent focus" is a term applied to lenses made up of two or more lenses, as the objective lens. It simply means that the combination will possess the same power of reduction or magnification possessed by a single, simple lens of equal focus. For example: if your objective is a 4½ inch E. F., then it will, working under the same condition, project the same size picture that a single lens of 4½ inch focus would project, the difference being that the single lens would not project nearly so good an image. Equivalent focus is of value to the operator for one thing, and one thing only, viz: in computing the focal length lens required to project a picture of given size at a given distance.

In order to understand lens action it is necessary to get the "viewpoint," and that is a very difficult thing to impart to the student. Each infinitesimal pinpoint on the surface of a lens is, from an optical standpoint, an entirely separate proposition from every other infinitestimal portion of the surface of that lens, since, because of the fact that a lens has curvature, each pinpoint of surface offers a different angle to the light, and therefore gives a refraction slightly different from that of the pinpoint next adjoining it, and a different retraction from that of all other points on its surface as well.

Remembering that the amount of refraction a light ray will receive upon passing from air to glass, or vice versa, will depend to a very large extent upon the angle at which the ray strikes the glass in entering, or strikes the air in leaving, and the further fact that, having entered the lens and received its refraction at the point of entry, the ray will travel (provided the glass be of even density, as it must be in a good lens) in a perfectly straight line until it strikes the other surface of the glass and re-enters the air, where it is again refracted, it will readily be seen that *the entire refraction takes place at the point of entry and exit.* It therefore follows that the refractive power of a lens depends entirely upon its *surfaces*, and that the glass underneath is of no value whatever, so far as refraction be concerned, except to act as a support for the surfaces. In fact in condensing

lenses the glass is a distinct detriment, in that it absorbs light in proportion to its thickness, but this is a necessary evil, since in order to accomplish a certain degree of refraction a lens must have a certain degree of curvature, and that curvature compels the use of a fixed amount of glass to act as its support.

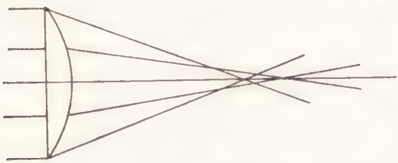


Figure 31.

This statement, however, must be qualified when it is applied to the objective lens, where combinations of crown and flint glass are used to correct faults. For instance: the front wide lens of an objective is very thick—often as much as three-eighths of an inch of glass being used, although the surfaces could be carried in their relation to each other by a far less amount. I assume, however, that this thickness is due to the fact that it is necessary to have a certain amount of flint glass in proportion to the amount of crown glass used, in order to fully correct chromatic aberration.

Spherical Aberration.—Spherical aberration is that quality of a lens which produces an uneven refraction or bending of the light rays at different portions of the lens. Rays passing through the outer edge of an uncorrected lens will be refracted or bent to such an extent that they will refocus at a point considerably nearer the opposite face of the lens than will those rays passing through nearer the center or optical axis of the lens. (See Fig. 31.)

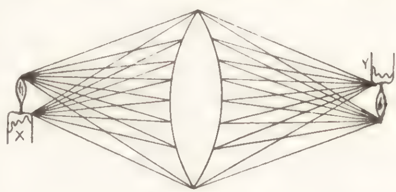


Figure 32.

The effect of spherical aberration on moving picture projection is not as yet thoroughly determined. It forms an interesting topic for future study. Spherical aberration is overcome or corrected by combining a concave lens with one having convex surfaces. These lenses must be so proportioned that the excessive converging powers of the outer surface of the lens is just counterbalanced by the diverging effect of the concave lens. (See Page 98.)

Chromatic Aberration.—Chromatic aberration is that quality of a lens which causes it to separate white light to a

greater or less extent into its primary colors. Chromatic aberration may be corrected or eliminated by a combination of flint and crown glass.

The objective lens is corrected for both spherical and chromatic aberration, and that is the reason for the four lenses and their different shapes. The form of the lenses corrects spherical aberration and their composition corrects chromatic aberration.

Now, assuming the lens in Fig. 32 to be free from spherical aberration, all the rays emanating from any point on light source X and striking the surface of the lens will be refracted in such manner that they will meet again at point Y, these two points being called the "conjugate foci" of the lens. If light source X be advanced nearer the surface of the lens, point Y, at which the rays meet again, will be automatically moved further away from the lens, and if point X, the light source, be brought near enough to the lens, point X finally will be lost, and rays will emanate from the lens in parallel, or even in diverging lines. On the other hand, if light source X be moved back further from the lens, point Y will be brought closer to its surface. In this connection a point of much importance in projection is the fact that, while the foregoing is strictly true when the light source is a pinpoint, it is subject to complications and modification in practice, because with a light source, say three-eighths inch in diameter, the rays emanating from a given point on one side of the crater will strike a given point on the lens at a different angle than will rays emanating from a given point on the opposite diameter of the crater. Just what and how much practical effect this has on projection I do not know, but certainly it has some, and forms an interesting topic for study. For one thing the large light source serves to secure a reasonably even illumination of the film picture, which would, due to spherical aberration in the condenser, be impossible with a very small crater.

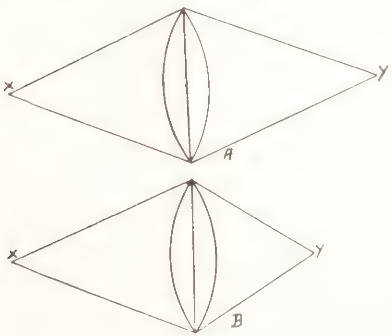


Figure 33.

At A, Fig. 33, we see a "long focal" length lens, which means one having slight curvature. Its refractive powers are not so great as the lens shown at B, Fig. 33, so that when light source X is at the point where X and Y are equidistant from the lens, as at A, and light source X and the lens are in the same relative position at B, point Y is much nearer the lens. The lens shown at A is a "long focal length" lens, and the one shown at B a "short focal length" lens, therefore you will observe that the heavier the curvature of the glass the shorter the focal length of the lens (the refractive index being equal); this by reason of the fact that the heavier the curvature the greater will be the angle at which the light rays strike the glass, hence the greater the amount of its refraction, and the nearer to the lens they will focus.

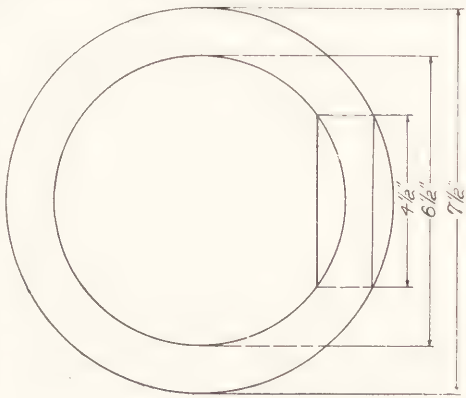


Figure 34.

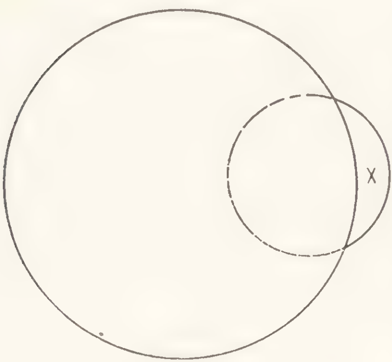


Figure 35.

The surface of lenses used for projection work is always a section of the surface of a true sphere. In Fig. 34 we see how the curvature of an ordinary plano-convex lens is determined. Assuming the outer circle to represent a glass ball 7½ inches in diameter, if you scribe on its surface a circle 4½ inches in diameter and then saw off the section so outlined and polish its flat side, you

would have a 7½-inch plano-convex lens. If the glass ball represented by the inner circle was 6½ inches in diameter, then a similar operation on the surface of that ball would produce a 6½-inch plano-convex lens. But a lens may have two curved surfaces, as, for instance, a meniscus, and the method of determining these surfaces is shown in Fig. 35, in which the two circles are made of a size to produce two surfaces which will give the effect desired, section X representing the resultant lens, which will have a convex surface on one side and a concave on the other. This is what is known as a "meniscus" lens. Its convex side is the "positive" and its concave side the "negative." In the lenses dealt with in Fig. 34, the inner or 6½-inch lens would be 6½-inch lens because it would focus parallel rays of light at a point 6½ inches from its optical center. On the other hand the lens cut from the outer circle would be a 7½-inch lens, because it would focus parallel rays to form an image at a point 7½ inches away; that is to say, it would do so theoretically. As a matter of fact, however, this is not precisely true, due to the fact that an uncorrected lens brings some rays to a focus nearer its surface than others.

Spherical aberration in the condenser is governed by the fact that when *parallel* rays strike a plano-convex lens on the curved side the spherical aberration is reduced to a minimum, but if the rays be diverging, then the spherical aberration is less if they strike the plano side. This, of course, means that to secure the least spherical aberration the flat side of the rear lens must be next the arc where the rays are diverging, and the convex side of the front lens must be toward the arc, since it receives approximately parallel rays from the rear lens. I mention this because some operators, though few, have a notion that they gain advantage by placing the curved side of the front lens next the machine aperture. This is an error. In fact, the actuality is the reverse, although but for the element of spherical aberration there would be little if any difference which way the lens was placed.

In order to actually focus the rays of light perfectly the lens must be "corrected" by the addition of one or more lenses having negative curvature.

As a matter of fact, the surface of a lens is really nothing more or less than millions of pin-points, each in effect a prism of minute dimensions. It is a well known fact that what we term "white light" is really composed of a number of colors. When white light, or what we call white light, is passed through a prism of glass, it is more or less separated into its primary

colors, or, in other words, the colors of which it is composed. The ordinary plano-convex is an uncorrected lens, and always carries the fault of chromatic aberration, which is the property of separating light more or less completely into its component parts or colors. This explains why you see a fringe of color at the edge of the spot on the cooling plate of the machine.

Now, taking the condensing lens for example, it being an uncorrected lens, remembering that, as I have said, its surface is composed of numberless minute prisms, you will readily see that the further away from the center of the lens you go the more acute will become the angle of these prisms with relation to the light source, or the light rays emanating from the source central with the optical axis of the lens, and therefore the more nearly true prism is approached. It then follows that, since the nearer we come to the true prism the greater will be the light separating power, we shall have a greater amount of chromatic aberration at the outer edge of the lens than at its center. Near the center of the lens the prisms will be very flat. Therefore their light-separating powers will be but slight; in fact, practically nothing at all. At the outer edge these powers will be considerable, and here is where one of the evil effects of spherical aberration as applied to projection makes itself apparent.

As already set forth, light rays near the outer edge of a lens will focus somewhat nearer the surface of the lens than will rays from near its center. This means that the excessive chromatic aberration at the outer edge of the lens is mingled with the purer light coming through the center of the lens, and the quality of the whole is thus injured. This is one of the reasons for my belief that there is advantage in the properly matched meniscus-bi-convex condenser combination. The addition of the negative curvature in the meniscus and the extra curvature in the bi-convex makes, in effect, a three and I believe a four lens combination, which has or ought to have to a considerable extent the effect of correcting spherical aberration. I do not state this as a positive fact. It has not yet been proven to my entire satisfaction, but I nevertheless believe it to be correct. There is, however, another decided advantage in the use of the meniscus lens next the arc, viz.: with a lens of given focal length the arc will be nearer the meniscus than it would be to a plano, hence a much greater amount of light will be transmitted to the screen.

It is also possible that a condensing lens with a poor, imperfect surface would have a considerable effect in injuring the definition of the picture. This seems to be made apparent in Fig. 51, which is a photograph of the light ray from a con-

denser covered with a metal plate in which about a dozen quarter-inch holes have been drilled at various points.

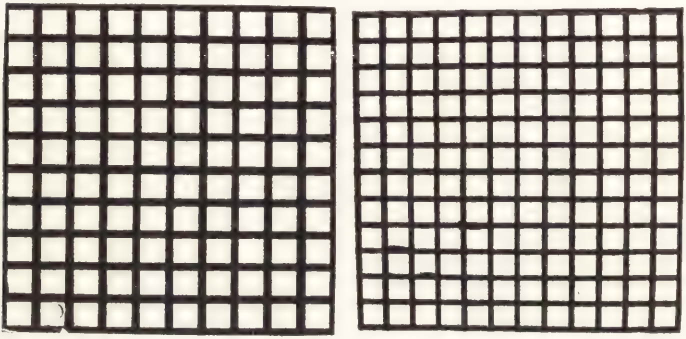
This photograph proves conclusively that a light ray passing through any given point of the condenser is carried forward to the screen, where it occupies a corresponding and magnified area. This being true, I cannot see but that any imperfection in the condensing lens which would in the least tend to alter the direction of a ray from the path it would have taken were the lens a perfect lens must of necessity injure the result on the screen, though Mr. Griffiths does not agree with this conclusion. However, I do not care to go deeply into this matter at this time, not being entirely sure of my ground.

The operator will have noted the fact that when the machine head is removed, and the white light projected to the screen without any objective lens, it is impossible to bring the light ray, as a whole, to a sharp point. Most operators have heretofore believed that the rays from the condenser were supposed to meet at a point and cross midway between the front and back factors of the objective lens. This is not true. See Page 118. The condenser does not bring the light ray as a whole to a point. It forms an image of the crater, and upon the size of the image thus formed will depend the diameter of the condenser light ray at its narrowest point. It is a mistaken idea to suppose that when we speak of a lens "focusing the rays" we mean that it brings the ray, as a whole, to a sharp point. It does not. What is really meant is illustrated in Fig. 32. All light rays emanating from any pinpoint of objective X and reaching the surface of the lens are refocused at a similar point in image Y. This image may be smaller than the original object. Study Fig. 32, and I think you will get the idea.

The Objective.—The objective lens of the moving picture projection machine consists of four lenses, two in the rear factor and two in the front factor. The two at the front are usually cemented together with Canadian balsam, so that, at a superficial glance, they appear to be one thick lens. As a matter of fact it is one thick lens, with a thin one cemented to the front so that the surfaces of the two lenses are brought into contact. It sometimes happens that the heat will melt the balsam and cause it to run down between the lenses. When this happens it is best not to try to fix it yourself, but send the lens back to the manufacturer to be recemented. However, you can separate the lenses (though I do not advise you to try it) by proceeding as follows: Set a shallow dish, filled with water, on

the stove, place the lens on a large kitchen spoon or tablespoon and set the spoon in the water, so that the lens will be covered. Allow the water to come to a boil and remove the lens quickly, shoving with your thumbs on one lens and pulling with your fingers on the other. It is a pretty hot job, and you will have to use considerable force, but if you bring the water to a boil it softens the balsam and you can get the lenses apart. The balsam can then be washed off with turpentine.

Distortion.—Operators should carefully test their objective lenses for distortion. This may best be done by taking a perfectly flat piece of mica, commonly known as isinglass, three or four inches long, and cutting it to the width of a film. Having done this, lay it off checkerboard fashion, as per Fig. 36, and put it in the machine, being careful to get it perfectly flat



A Figure 36. B

over the aperture, and project its image to the screen. At A, Fig. 36, we see no distortion. At B there is what is known as barrel distortion, which amounts to a curvature of the lines. The lens which projects B is not a good lens, whereas the lens which projects A is practically perfect. The scratch marks on the mica may be made with the point of a knife blade, or any other sharp instrument. The lines on the mica must be *perfectly* straight, and if their image on the screen is not perfectly straight (test by streching a line) the lens is imperfect.

A lens must focus all light rays passing through a pinpoint in the photograph to a corresponding though magnified point on the screen. The distance at which this focusing will be accomplished depends, within limits, upon the distance of the film from the lens—the back focus at which the lens is working.

This is diagrammatically illustrated in Fig. 37, in which arrow A is being projected and focused at point 1. That is to say: With the arrow at the distance from the lens, as shown, the rays will meet and cross at point 1, where they begin to diverge. If the screen be placed at point 2, arrow A remaining its original distance from the lens, instead of an image on the screen, each portion of arrow A will be represented by a blurred ring. If the distance of arrow A from lens B is altered, then the distance at which the rays meet and cross (image) will be altered, and the screen will have to be moved toward or from the lens a corresponding distance. This explains why it is necessary to move the lens in and out in order to focus the picture on the screen. Where the back focus is short, as in a moving picture lens, a slight alteration of the distance between the lens and the film makes a decided difference in the distance at which the rays of light will focus.

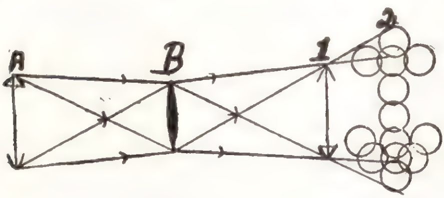


Figure 37.

Doctoring Lenses.—The question is often asked: "Can the E. F. of a lens be altered by shortening or lengthening the barrel, so as to alter the distance between its two factors?" Yes, but it is not advisable to try anything of that sort. The chances are that you will ruin your lens. This scheme has been known to work fairly well in some instances, but more often than not it is more or less of a complete failure.

Bringing the two combinations closer together or separating them farther apart would have the effect of altering the size of the picture on the screen at a given distance, but it is a very poor way of doing it.

The author has frequently been asked whether or not the same lenses may be used to project a picture at different distances. Yes. But it must be understood that if the distance be made less, then the picture will be smaller, and if the distance be made greater the picture will be larger. Also moving the screen will alter the back focus at which the lens will work. The shorter the distance between the lens and screen the farther the lens must be from the film, and vice versa.

Spread of Ray.—It is easy to figure how much change in size of picture will be accomplished by moving the screen any given distance. Suppose you have a lens which projects a 10-foot picture at 60 feet. It is readily seen that if the width of the picture be divided by the number of feet it is projected the result will be the fraction of a foot its width increases with each foot of distance, hence in this case we have $10 \div 60 =$ one-sixth of a foot, or 2 inches, which is the amount the light ray spreads for each foot of distance between the lens and screen. In proof of this, multiply 2×60 and we have 120 inches, or 10 feet. Now, if you move your screen back five feet farther you will have $2 \times 5 = 10$ inches additional width of picture, or if we brought the screen 6 feet nearer the lens, then we would have $2 \times 6 = 12$ inches less width of picture.

Improving Definition.—The work of a projection lens which does not give sharp definition may sometimes be improved by cutting a circle of stiff dark paper, just large enough to fit tightly into the front end of the lens barrel and up against the front lens. In the center of this ring cut a circular opening, the correct size of which must be determined by experiment in each individual case. Usually it is not advisable to stop down more than one-fourth the diameter of the opening. This is often of benefit in sharpening the focus where the machine sets above or to one side of the screen, because reducing the lens diameter has the effect of increasing its depth of focus.

Dirty Lenses.—It is of the utmost importance that the operator keep his lenses scrupulously clean. "Optical Projection," by Simon Henry and Henry Phelps Gage, gives the losses by reflection from the polished surface of each surface to each lens as from 4 to 5 per cent., or a total of 8 to 10 per cent. for each lens or plate of glass, and further remarks that if the surface of the glass be not perfectly clean or perfectly polished the light loss may amount to much more—say 15 per cent. at each surface.

It really seems to me that this cannot be true. There being eight surfaces in an objective lens, or since two of them are in direct contact, let us say six, even taking the lowest figure, viz., 4 per cent. for each surface, we would have a total of 24 per cent. loss by reflection alone. However, without discussing the probable correctness of the percentages, it is an undoubted fact that there is considerable loss through reflection, and this loss will be very largely increased if the lens be dirty. Therefore, it is very much up to the operator to keep his lenses not only clean but polished as highly as possible.

Measuring Lenses is a very simple operation. In order properly to match up a projector lens system it is necessary that the operator be able to measure and determine the exact focal length of his condenser lenses, and it is often very desirable that he be able to measure the exact equivalent focus of an objective in order that he may determine what size picture it will project at a given distance.

Plano-convex lenses may be measured as follows: Pin a sheet of white paper to the wall of a room, opposite a window, hold the lens up with its flat side toward the wall and, through the open window, carefully focus some building, trees, or other object located at a considerable distance outside the window, on the paper screen. *It is essential to accuracy that the object being focused be a goodly distance away*—the farther the better—because in these measurements the light rays are presumed to enter the lens in parallel lines, and unless they do enter in approximately parallel lines there will be error in the result. Be sure to get the lens in exact position where the focus of the image on the paper screen is most sharp, and then measure from the flat side of the lens to the wall, making a note of the precise distance. Next turn the lens around and with the convex side toward the wall, again carefully focus the same object on the paper screen and measure from the wall to the flat side of the lens. It will be found that the two measurements will differ considerably, and their sum divided by 2 will be the focal length of the lens. For instance: Suppose one measurement to be 6 inches and the other 7 inches: $6 + 7 = 13$ which divided by $2 = 6\frac{1}{2}$, therefore it is a 6½ inch lens.

It is not practical to measure condensing lenses with any great degree of accuracy. There is so much spherical aberration in these uncorrected, comparatively cheap lenses, that the picture cannot be focused with absolute sharpness. The focal length of the lens may, however, be arrived at by the foregoing process closely enough to serve all practical purposes.

The measuring of a motion picture objective or stereopticon lens is a very simple operation. The focus of a projection lens may be designated in two ways—viz., back focus (commonly expressed as b. f.) which is the measurement often used by the film exchange, and equivalent focus (commonly expressed as e. f.), which is the measurement used by the lens manufacturer. Therefore *in ordering lenses of a given focal length one should be careful to state whether the measurement given represents b. f. or e. f.* The e. f. is the measurement which must be used in ordering lenses to project a picture of given distance.

To measure a moving picture objective or stereopticon lens pin a sheet of white paper to a wall opposite a window. Hold the lens square with the paper screen and, through the open window, focus some building, tree, or other distant object on the paper screen; be very careful to get the image as sharp as you possibly can. Now measure from the wall to the surface of the lens nearest the screen, and that measurement will be the back focus, or b. f. of the lens. If, instead of measuring from the surface of the lens to the screen, you measure from a point half way between the front and back combinations of the lens (half way between the lenses at either end of the tube) to the paper screen, that measurement will be the equivalent focus,

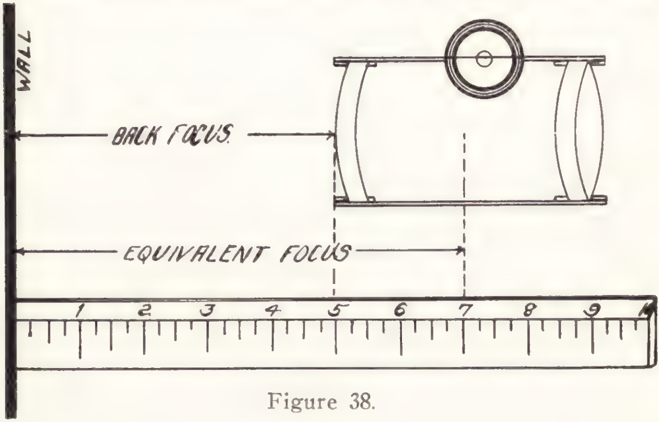


Figure 38.

or e. f. of the lens. In other words the e. f. is equal to the b. f. plus half the distance between the two combinations of the lens. All this we see diagrammatically represented in Fig. 38.

Again let me caution you always to focus some DISTANT object: an object which is 100 feet away will do, and even an object 25 feet away will not be close enough to affect the result very much. It is even possible to get an approximate measurement by focusing an incandescent light, provided it be at least 10 or 15 feet away, but such a measurement cannot be depended upon when accuracy is essential. Also see Page 108.

The use of these measurements, as applied to the objective, becomes apparent when we learn that the size of the picture which will be projected by any lens at a given distance from the screen will be entirely dependent upon the focal length of the lens. The shorter its focal length the larger will be the

picture at a given distance, and the longer its focal length the smaller will be the picture at a given distance. A lens having a 4-inch e. f. will project a much larger picture at 50 feet than will a lens having a 6-inch e. f.

Nearly all machine and lens manufacturers put out tables designed to tell one the exact size (width) picture a lens of given focal length will project at a given distance. These tables are useful as applied to stereopticon lenses, but have slight value as applied to the moving picture objective—this by reason of the fact that the size of picture is based upon a given width of aperture, which, in the case of the stereo, is supposed to be 3 inches, but which may vary widely with each set of slides (the aperture in the case of the stereopticon is the width of the standard slide mat); hence, by reason of the variation in the size of slide mats it is impossible to figure the size of a stereopticon picture with any degree of accuracy, and the table will therefore answer about as well as measurements.

As applied to the motion picture objective, however, these tables are not at all satisfactory. As a rule operators and managers want their picture not approximately, but exactly a given width. Now there are at the present time two different standards of motion picture machine aperture widths, viz., 15/16 and 29/32; also the aperture of the older machines of different makes, while they were presumed to be all 15/16 of an inch, really varied considerably, and a slight variation would make considerable difference in the size of the picture on the screen, as for instance, if you used 15/16 of an inch as a basis for figuring, and the aperture really was a little more or a little less than that width, then the result would be a picture wider or narrower than your figures called for. This being the condition, you can readily see that tables cannot be depended upon for any very great degree of accuracy in results. I will, however, for reasons already set forth, append one of the tables for stereopticon lenses.

To figure the necessary equivalent focus of a lens to project a picture of given width at a given distance proceed as follows: *Have a machinist measure the aperture of your machine accurately with an inside caliper and a micrometer. Measure the exact distance from the lens to the screen. Multiply the distance from the lens to the screen, in feet, by the width of the aperture, in fractions of an inch, and divide the result by the width of the picture you desire, in feet. The result will be the e. f. of the lens required to project a picture that width, and will be as close to it as you can get at it by figuring.* For instance: Suppose you want a 15-foot picture at 60 feet. The machine

aperture is found to be 29/32 of an inch (the new standard) wide. First multiply the distance from the screen in feet by the width of the aperture in fractions of an inch. To multiply 60 by 29/32 we first divide by 32 and multiply the result by 29; $60 \div 32 = 1.875$; $1.875 \times 29 = 54.375$. Next we divide this measurement by the desired width of picture in feet: $54.375 \div 15 = 3.625$, or a 3⅝-inch e. f. lens. We most likely would be unable to get that exact focal length and would have to take, instead, a 5¾-inch e. f. lens.

It must be understood, however, that the great bulk of projection lenses now in use are cheap lenses, and cheap lenses, like all other cheap things, are inaccurate, therefore you cannot expect to arrive with certainty at precisely the result you desire in any other way than by actually testing the lenses.

The stereopticon lens is figured exactly the same way, except that instead of measuring the aperture width, we take 3 inches as the average width of the slide mat—the slide mat, in this case, being the aperture.

It is also entirely practical to make other measurements of practical value as follows: Suppose you have an objective and wish to know what size picture it will project at a given distance. First measure its e. f. as already directed and then:

Size of Image.—This can be determined by multiplying the difference between the distance from lens to screen and the focal length of the objective, by the width of the aperture and dividing the product by the focal length of the lens. For example: Let L be the projection distance, 40 feet (480 inches); S, the slide mat, 3 inches; F the e. f. of the lens, 12 inches; we then have the formula (in which d is the size of image);

$$d = \frac{S\ (L - F)}{F}$$

Substituting for the letters their known values, we have:

$$d = \frac{3\ (480 - 12)}{12} = 117 \text{ in., or } 9\tfrac{3}{4} \text{ feet,}$$

as the size picture a 12-inch e. f. stereo lens will project at 40 feet, provided the slide mat be just 3 inches wide. If. however, the mat be more or less than 3 inches, then the picture will be wider or less wide.

Distance from Slide to Screen.—With the other factors given we get this by multiplying the sum of the width of the

Showing Size of Screen Image When Lantern Slides Are Projected

Size of Mat Opening, 2¾ x 3 Inches

Table 7, Figure 39

Equiv. focus Inches	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
5	8.0	10.8	13.5	16.3	19.0								
	8.8	11.8	14.8	17.8	20.8								
5½	7.3	9.8	12.3	14.8	17.3	19.8							
	7.9	10.7	13.4	16.1	18.8	21.6							
6	6.6	8.9	11.2	13.5	15.8	18.1	20.4						
	7.3	9.8	12.3	14.8	17.3	19.8	22.3						
6½	6.1	8.2	10.4	12.5	14.6	16.7	18.8						
	6.7	9.0	11.3	13.6	15.9	18.2	20.5						
7	5.7	7.6	9.6	11.6	13.5	15.5	17.5	19.4					
	6.2	8.3	10.5	12.6	14.8	16.9	19.0	21.2					
7½	5.3	7.1	8.9	10.8	12.6	14.4	16.3	18.1					
	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8					
8		6.6	8.4	10.1	11.8	13.5	15.2	17.0	20 4				
		7.3	9.1	11.0	12.9	14.8	16.6	18.5	22.3				
8½		6.2	7.9	9.5	11.1	12.7	14.3	16.0	19.2				
		6.8	8.6	10.3	12.1	13.9	15.6	17.4	20.9				
9		5.9	7.4	8.9	10.5	12.0	13.5	15.1	18.1	21.1			
		6.4	8.1	9.8	11.4	13.1	14.8	16.4	19.8	23.1			
9½		5.6	7.0	8.5	9.9	11.4	12.8	14.2	17.1	20.0			
		6.1	7.6	9.2	10.8	12.4	14.0	15.5	18.7	21.9			
10		5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8		
		5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.8		
12			5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.4	
			6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.3	
14				5.6	6.6	7.6	8.6	9.6	11.6	13.5	15.5	17.5	19.4
				6.2	7.3	8.3	9.4	10.5	12.6	14.8	16.9	19.0	21.2
16					5.8	6.6	7.5	8.4	10.1	11.8	13.5	15 2	17.0
					6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
18					5.1	5.9	6.6	7.4	8.9	10.5	12.0	13.5	15.1
					5.6	6.4	7.3	8.1	9.8	11.4	13.1	14.8	16.4
20						5.3	6.0	6.6	8.0	9.4	10.8	12.2	13.5
						5.8	6.5	7.3	8.8	10.3	11.8	13.3	14.8
22							5.4	6.0	7.3	8.5	9.8	11.0	12.3
							5.9	6.6	7.9	9.3	10.7	12.0	13.4
24								5.5	6.6	7.8	8.9	10.1	11.2
								6.0	7.3	8.5	9.8	11.0	12.3

EXAMPLE: With a lens of 10-inch focus at a distance of 20 ft. the screen image will be 5.3 x 5.8; at 25 ft., 6.6 x 7.3; at 30 ft., 8.0 x 8.8; at 50 ft., 13.5 x 14.8 etc.

image and width of the slide mat, by the focal length of the lens; dividing this product by the width of the slide mat, thus:

$$L = \frac{F\,(d + S)}{S}$$

Substituting values, $L = \dfrac{12\,(117 + 3)}{3} = 480$ inches $= 40$ feet.

Measuring E. F. Accurately.—Should the operator desire to measure the e. f. of his objective with absolute accuracy he may proceed as follows: Remove the mechanism and in the position the aperture of the machine occupied place a sheet of tin having an aperture about three-quarters of an inch square. Now hold the lens out at a distance about twice the length of its supposed e. f., in front of the aperture, with the light turned on, and an equal distance in front of the lens (still further out) hold a small screen, preferably dull black in color, and move the lens and the screen until the image of the aperture on the screen is exactly the same width as the actual aperture. Now measure the distance from the aperture to the screen and divide it by 4; the result will be the exact e. f. of the lens.

Cleaning Lenses.—It is of the utmost importance that lenses be kept scrupulously clean. Oil and fingermarks are particularly objectionable. I have been called to theaters to locate the cause of lack of sharp focus in the picture, only to find that the operator had had his objective apart to clean, and in putting it together had inadvertently lightly touched one of the interior surfaces of the lens with his finger. The mark was so slight that it could not be detected by looking through the lens, but was quite visible when the lens was taken apart and looked at from an angle. Slight as this mark was it seriously injured the definition of the picture.

Oil on the surface of a lens will also operate to injure the focus of the picture. I do not think any argument is necessary on this particular point.

It is absolutely essential to sharp definition of the picture on the screen that all lenses be kept scrupulously clean.

The careful painstaking operator, whose machines run several hours each day, will *clean his condensing lenses every day,* particularly the one next the arc. The objective lens need not be cleaned more than perhaps once a week, unless oil spatters on its rear surface, in which case it should be cleaned just as soon thereafter as possible, and if there is tendency of oil

to spatter on the lens its rear end should be protected by some kind of a metal guard. I cannot tell you just now how to do this, because the method would vary with different mechanisms, but certainly the competent operator can devise ways and means to keep the oil off the rear end of his lens. In some cases a collar of tin made tight enough to clamp the rear end of the lens barrel, extending back nearly to the aperture, will answer the purpose.

Unless there is oil on the lens I know of no better way of cleaning them than by breathing on the cold glass and polishing with a perfectly clean chamois, or an old, clean, soft handkerchief. Always provided there be no oil present, this will clean the surface of the lens perfectly, and will answer every purpose. If there be oil on the lens, then I recommend the use of a solution of one half alcohol and one half water. Wash the lens off with a cloth saturated with the solution, and polish quickly with a dry, soft, clean handkerchief, perferably an old one. Nothing makes a better lens cloth than an old, worn out handkerchief, after having been laundered. Some operators prefer a solution of ammonia and water or water and alcohol.

The operator should, perhaps twice a year, take his objective lenses apart and clean their interior surfaces, being very, very careful that in putting them back he does not touch their surface with his fingers. This latter is of the utmost importance, because the very lightest touch will leave a mark which, while invisible when looking through the lens, is likely to seriously injure its work. In replacing the objective lens factors always put them together so that the heavy bulge or convex of all lenses is toward the screen. In taking out the rear combination be careful that you put them back in the same position they were in. In other words, don't get their position switched. The best way to go about this is to lay a sheet of paper on a table and write "rear lens," "inside lens," and "front lens," at different places on its surface. Now as you take the lenses out lay the rear one (next the aperture) on the space marked "rear lens," the inside one on the next space, and the front on the space marked "front lens." Then you cannot very well make any mistake. You will find a spacing ring between the two rear lenses. Be sure and get it back in its place when you put the lenses together.

Fig. 40 shows the position of the lenses in an objective. The two front lenses are cemented together with Canadian balsam. (See Page 100.)

Selecting Condensing Lenses.—See Page 127.

Lens Diameter.—Lens diameter is a subject of much importance. With a point source of light it would be quite impossible to use a very small diameter and place the arc right up close to it. Modern practice, however, is to use an amperage for the projeection of moving pictures which produces a crater varying from (D. C.) one-quarter to one-half inch in diameter. This, of course, means a light source of very high temperature, and more or less flaming of the carbons, so that the light source cannot be brought very close to the lens. So far as the condenser be concerned, as a rule the diameter of the lens next the arc might be 4 inches as against a 4½-inch diameter for the rear lens without increasing light loss; this by reason of the fact that the condenser next the arc usually, with the arc in operating position, produces a diverging ray beyond the lens, and it is only necessary that the front lens have sufficient diameter so that the light from it will just cover the front lens. This is not intended to mean that the author expects any change of this kind will be made. It is simply an interesting point, though in England and Germany use is made of a lens next the arc which has a smaller diameter than the front lens. Four and a half inches seems to be fairly satisfactory diameters for condensers. Whether there would be, considering the proposition as a whole, any gain in using a larger diameter condenser I am not quite sure, but doubt it.

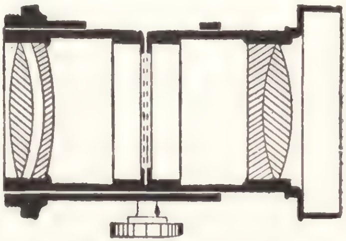


Figure 40.

The diameter of the objective lens is a matter of the utmost importance. See Page 121 and Fig. 49.

High-Grade Lenses.—The author of this work is thoroughly and completely convinced that it is a tremendous mistake to use cheap objective lenses for projecting the picture. This most emphatically is not the result of snap-shot judgment, but a conviction which has been growing for some years which was finally clinched by knowledge of the fact that the better English theaters are using lenses costing as much as £12 (approximately $60), supplemented by absolute proof that there is a very large possible gain in illumination and sharpness of focus by using a high class objective lens.

The projection of the picture is nothing more or less than a reversal of the process of its photographing. Film manufacturers spare no expense in procuring the best lens obtainable for their cameras. These lenses are a magnificent example of the optician's art. They must have great "depth" and plenty of "speed." They must be corrected for about every imaginable fault, and the result is that they register on the film a wealth of detail, depth, and sharpness which are largely lost by reason of the fact that the photograph must be projected by about the cheapest lens it is possible to obtain.

Authorities in England, where they have already made considerable progress in the high-grade projection lens business, claim that in order to get a perfectly flat field it is necessary that an anastigmat lens be used. I cannot vouch for the correctness of this, but am told by lens men here in America that it is true.

These same authorities who have experimented with high-class objectives for the projection of pictures claim that the high-class lens will pay its additional cost within a comparatively short time in current saving, it being the fact that these lenses give a greater illumination per ampere of current than do the ordinary objectives now being used. This I personally have seen demonstrated.

Just reason with yourself for a moment. If the cheap lens is the right thing with which to project a picture, then why is it not the proper thing to *take* the picture with? Why take a picture with a costly, high-class lens and project it with a cheap, comparatively poor article. It doesn't sound like common sense, does it, gentlemen?

I notice that no less a person than Simon Henry Gage, Cornell University, a man deeply versed in the science of optics, in his work on "Optic Projection," says there is no particular value in having a perfectly sharp picture if it is to be viewed at a considerable distance. He even says a little coarseness is an advantage. With this I cannot at all agree. I have the utmost respect for the knowledge of Professor Gage, but in this one particular thing I think he is decidedly in error, and, moreover, assuming he is right, it must be remembered that a goodly portion of the audience is seated compartively near the screen.

The writer makes no claim to being an expert in lenses—far from it. He does, however, claim to be the possessor of a considerable fund of common sense, and common sense tells him that the sharper the picture is the better for all

concerned. Moreover, flatness of field is to be highly desired, since curvature of field means there will be a tendency to out-of-focus effect at the edges when the center is in focus, and vice versa. This may or may not be sufficient to be noticeable, but is apt to be very much so with short focal length lenses. It is in the nature of things, and cannot be otherwise unless the lens is corrected to produce a flat field, and as I understand it that means an anastigmat lens.

I would strongly advise theatre managers to purchase high-class lenses for their projectors. I would even advise them to have no hesitation in paying as much as sixty dollars for a good lens. The Kleine Optical Company, Chicago, is handling high-grade lenses. The Dallmyer lenses are handled by Burke & Jones, New York City and Chicago, and the other European manufacturers producing high-class projection lenses also have their representatives in this country.

Just at present it may be difficult to secure just the right kind of lens, but I have had proof of the fact that the lenses handled by Mr. Kleine, listed from thirty to sixty dollars, are a very good article, and worth every cent of their price.

LINING THE OPTICAL SYSTEM

In order to insure the best possible results on the screen it is essential that the light source (crater), the optical axis of both condensing lenses, and the optical axis of both combinations of the objective be exactly in line and square with

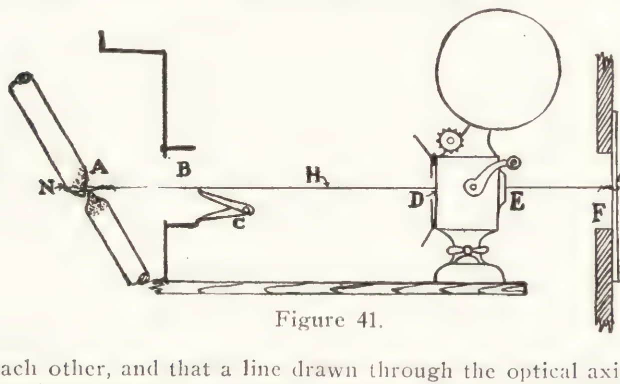


Figure 41.

each other, and that a line drawn through the optical axis of the lens system shall pass precisely through the center of the aperture of the projector.

In Fig. 41, A is the crater, B the lamphouse condenser opening with the condensers removed, D the aperture of the projector, E the objective lens barrel, with the lenses removed, and F the opening in the wall of the operating room. H is a stand of white sewing thread or a fine copper wire, G is a light metal rod placed across the opening in the operating room wall, and supported by string H being drawn taut The method of procedure is as follows: First remove the condensing lenses and remove the lens factors from the objective, but leave the barrel screwed firmly in its place in the lens ring. Next attach cord or wire H to rod G, and pass the cord or wire through the lens barrel and machine aperture, as shown, and bring it back and tie it around the point of the upper carbon. After all is ready pull the lamp back by its forward and backward adjustment (before beginning it should be shoved clear ahead) until string or wire H is pulled tight—just tight enough so that rod G will be held in place and the string or wire be perfectly straight. Now with caliper C carefully center cord or wire H in condenser opening B, machine aperture A, and *both ends* of objective lens barrel E, moving whatever may be necessary to accomplish the purpose. I cannot tell you what you will have to do to get the string in the center since this will vary in different cases: it will have to be left to your ingenuity.

No attention should be paid to hole F in the wall as that has nothing whatever to do with the lining except to support rod G which holds the string in place. The fastening of the cord to the carbon point will be facilitated by using a three cornered file and filing a small notch at N.

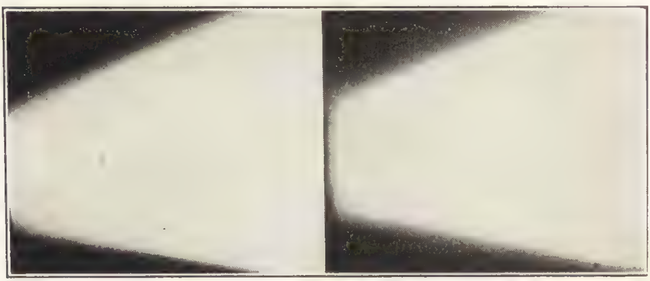
Matching Up the Lens System

THE action of light rays through a projection system has been the subject of much controversy, and I believe it might fairly be said that until the projection Department of the *Moving Picture World* undertook a series of experiments and went into an exhaustive study of the matter, no very intelligent explanation of the action of light rays through the projector system had ever been promulgated—that is to say, no explanation which "squared up" with what apparently actually took place.

The main stumbling block in this proposition lay in the fact that the same conditions do not obtain in the projection of moving pictures that obtain in stereopticon projection; a

fact which opticians have failed to observe, attacking the problem of projecting moving pictures from the same standpoint as of projection lantern slides. The difference in the two problems lies in the following: In stereopticon projection the object (slide) is situated right up against the condensing lens, whereas in moving picture projection the object (film), is at, or near the crater image—a foot or more away from the condenser, and at one of the conjugate foci points of the condenser system. This means that the two problems present very different angles. In order to obtain maximum illumination in stereopticon projection the crater image must be approximately central between the two factors of the stereopticon objective lens, whereas in moving picture projection it must be at or near the object (film).

The author does not believe this matter to be, as yet, entirely solved, but he does believe that great progress



A B

Plate 1, Figure 42.

has been made, and that the tables representing that progress which are hereto appended will be found to be approximately correct, and that they will, barring the limits imposed by present day apparatus, enable the operator to match up his projector lenses in a way to give very satisfactory results.

In this connection we are especially indebted to John Griffiths, Ansonia, Conn.; W. S. James, formerly of Camden, N. J.; C. D. Armstrong, Ashland, Wis.; and L. C. LaGrow, Albany, N. Y. These men have aided very greatly in the solving of this difficult problem and Griffiths has contributed the greater portion of the theory upon which the tables are based, as well as worked out the tables themselves.

The Condenser.—The spacing of the two condenser lenses different distances apart has the effect of altering the equivalent focus of the combination. *The further the lenses are spaced apart the longer will be the E. F. of the combination,* and vice versa.

It seems, however, that, in view of the fact that with the arc at ordinary operating distance from the rear condenser lens, the light ray diverges after passing through the rear lens (see A-B, Plate 1) and that, incidently, this divergence increases with increased focal length of the rear lens, it is advisable that the condensing lenses be placed as close as possible to each other (without actual mechanical contact, which latter would tend to convey heat to the front lens), since the further apart the lenses are the greater must be the loss through the aforesaid divergence of the light ray. A and B, Plate 1, show a 6½ and a 7½ lens, with the arc the same distance from the lens, using equal amperage in both cases. Even with the lenses set so that their curved surfaces are within one-sixteenth of an inch of each other there will still be some loss, but this cannot be avoided, since if we pull the arc back far enough to bring the light rays parallel after passing through the front lens, then we will encounter still greater loss on the arc side of the lens, by reason of increased distance between the arc and the lens and the law that intensity of illumination decreases inversely with the square of the distance from the light source.

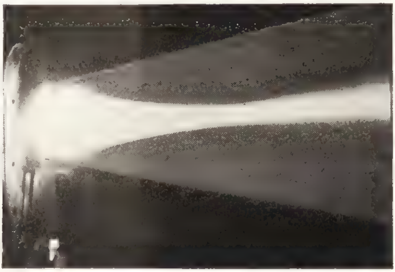


Plate 2, Figure 43.

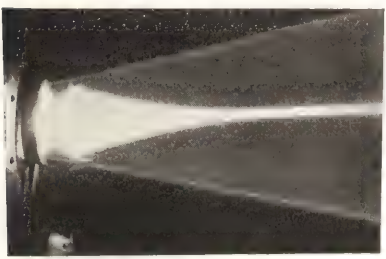


Plate 3, Figure 44.

Plates 2 and 3 illustrate the relative loss through spacing of the lenses, Plate 2 shows the lenses set with their curved surfaces approximately one-sixteenth of an inch apart. Plate 3 shows the lenses spaced so that their curved surfaces are one-half inch apart. It will be observed that the loss of light is materially greater in Plate 3 than in Plate 2.

It is also of interest to note the difference in the light beam itself. In Plate 2 the beam does not narrow down quite so much as it does in Plate 3, and the crossing point of the

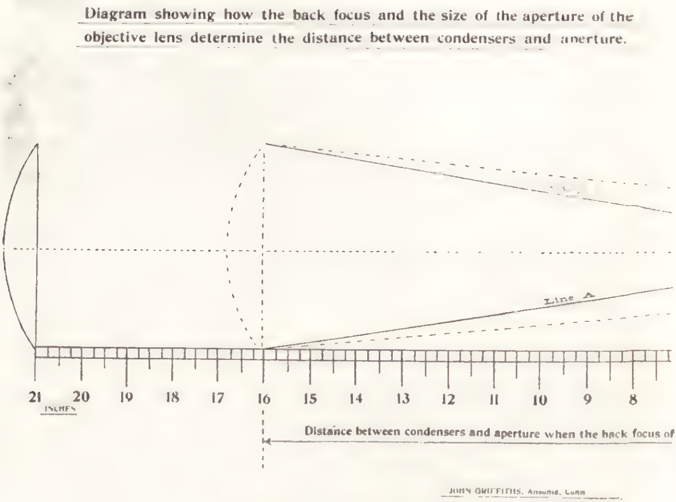


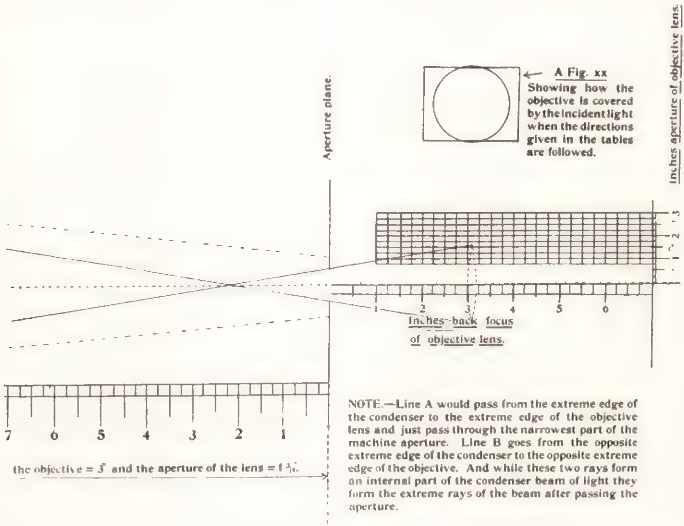
Plate 4, Figure 45.

rays is much nearer to the lens, which means that the E. F. of the combination has been lengthened by spacing the lenses. However, due to reasons already set forth I believe it is better practice to *work with a fixed E. F., setting the condensing lenses so that their curved surfaces are not more than one-sixteenth of an inch to one-eighth of an inch apart, and make other conditions fit this one.*

Never have the lenses actually touching each other, since mechanical contact would serve to impart considerable heat to the front lens, which is decidedly undesirable.

The novice would probably say that, since the light cone is shorter in Plate 3 than in Plate 2, the E. F. of the Plate 3 combination would be less. The opposite is true, however, Measurement from a point half way between the two lenses to the point where the rays begin to diverge from the main beam will show that the cone is shorter in Plate 2 than in Plate 3.

It may be stated as an absolute fact that when the condenser is made up of two factors of different focal lengths, as for instance, a 6½ and a 7½ lens, the better practice is to



place the shorter focal length lens next the arc. This is proven by A-B, Plate 1. The only objection to so doing is that the thick lens is more apt to break than is the thinner one, but this may be very largely if not entirely overcome by the installation of a modern condenser mount, of which the Elbert or Preddy (see index) are excellent examples.

In the course of the aforementioned experiments it has been proven to the author's entire satisfaction that, provided the front lens of the condenser combination be in line with and square with the aperture and objective, the fact that the

rear condensing lens it not exactly square or in line with the front one does not make any serious difference, provided, of course, that the fault be not too great. I do not wish to be understood as saying that this condition ought to be allowed to obtain. The better practice is to have the entire lens system in exact line, but with present projector mounts this is a somewhat diffcult thing to accomplish, and failure to accomplish the lining of the two condenser factors perfectly with each other will not be a very serious matter.

Another extremely important relation between the condensing lens and the objective is illustrated in Plate 4, in which A represents the extreme limit of light from the lower edge of the condensing lens when it is placed 16 inches from the aperture of the machine. You will observe that with the condenser at a distance from the aperture which will place the arc in focus (the point where the condenser ray begins to diverge), which is the point where the picture will receive evenly distributed illumination, the light will pass through the aperture and become a diverging beam. This is clearly shown in Plate 5, which shows the light beam as in actual projection, and is proven in Plate 6, in which the condenser is covered by a metal plate in which are two holes located diametrically opposite each other and about a half-inch from the edge of the lens. It will be seen from Plate 6 that the rays from the outer edge of the condenser lens actually do act precisely as indicated in diagram, Plate 4. In Plate 7 the same two rays are passed on through the objective lens.

From this the inevitable conclusion is reached that, with the crater in focus at the aperture, the closer the condenser is to the aperture *the more rapid will be the divergence of the beam beyond the aperture,* though the increase from this will be comparativetly slight. It will also be seen that *the greater the distance from the aperture plate to the objective lens aperture the wider the light beam will be at the point it encounters the lens, See Plate* 8. It therefore is an undoubted fact that *the diameter of the objective lens is an exceedingly important factor, particularly with long focal length lenses, and it is a factor which must be taken into very serious account in the matching up of projector lens systems.*

Plate 9 shows the loss of light through using a lens of too small diameter. This loss may be slight or it may be very great. In many cases it is the latter. In this case the loss is far greater than appears, because the camera only caught the loss which fell outside the lens barrel, whereas

Plate 5, Figure 46.

Plate 6, Figure 47.

Plate 7, Figure 48.

the actual diameter of the lens aperture is considerably less than the outside diameter of the barrel.

In Plate 4, the long scale marks condenser distance, and the short scale, to the right, indicates the back focus of the objective. Any objective lens may work at any one of several

Plate 8, Figure 49.

Plate 9, Figure 50.

different distances from the film. That is something I have never been able to make fit in with any plan I could evolve for matching up a projector lens system. Like most other things, however, once you get hold of the right key

it is very simple, and the key to this particular problem is "back focus."

In matching up a projector lens system, first, using the well-known formula for finding the equivalent focus of the lens required to project the size picture you want at the distance your condition calls for, determine the E. F. of the lens you want, procure it, mount it in the machine, and, using any condenser, project a picture, and very carefully adjust the objective until the picture on the screen is in sharp focus. Having done this, stick a rule through the aperture and, with its end against the lens, measure the *exact* distance of the rear surface of the rear combination of the objective from the film track surface on the aperture.

This measurement will be the BACK FOCUS at which your lens will work, and it is this measurement and *not* the equivalent focus, which must be used in matching up the lens system. The E. F. has absolutely no value whatever except to enable the operator to select the proper lens to project the size picture he wants at the given distance.

At this point we reach an item of much importance, concerning which positive data cannot as yet be given, viz.: The selection of an objective lens of the right diameter to fit local conditions. Excess in diameter is undesirable, in that it is likely to set up trouble in the shape of travel ghost. Insufficient diameter, on the other hand, means loss of light, and loss of light is expensive. On the whole, it is much better, I believe, to get a lens of too large than too small diameter, because it is an easy matter to stop down the large lens to just the size needed, whereas the small diameter cannot possibly be made larger.

On the whole, I think the best recommendation we can make at present is that the E. F. of the required lens be found, and that a lens be ordered having a diameter equal to one-half its E. F., up to 4½ inches E. F., the diameter beyond that focal length to remain fixed at 2¼ inches, up to 7 inches E. F., beyond which it might possibly be increased to 2½ inches with advantage. When the lens is received, place it in the machine and focus the picture sharply on the screen, then measure the back focus, as already directed, and remove the lens. Now place a sheet of white paper inside the mechanism in the exact position occupied by the back surface of the lens, supporting it in any convenient way, *without having changed the position of the lamp with relation to the condenser or of the lamphouse with relation to the aperture,* strike an arc, and measure

Plate 10, Figure 51.

the light on the paper. If the lens measures 2 inches in diameter and the light measures 2 inches across, all is well. If the light measures more than 2 inches across, but only 2 inches up and down, the lens still will do fairly well, though there will be some loss. If, however, the lens measures greater than the light, stop the lens down to the diameter of the light *at both ends,* by means of rings of metal in which you have made a circular opening of proper size. I do not pretend to say that this advice is perfect. It is, however, the best I can offer at this time, and is, I am sure, based on the right idea.

A Digression. Let me pause here, for want of a more fitting place, and digress for a moment to show you an interesting light ray picture.

In Plate 10 we see a condenser with a metal plate having a number of holes, each about one-quarter inch in diameter. This picture has no considerable value, except to allow the operator or student to trace the light ray action on both sides of the objective. It will be noted that the screen illumination is not complete, especially at the outer edges where there were but few holes in the metal plate. Another interesting point in this picture is the circle of light on the back side of the aperture plate, showing the loss of light through reflection from the polished surface of the lens. In fact, there are a number of things in this photograph that will interest the student-operator.

Spherical Aberration.—An examination into the effect of spherical aberration points to the fact that it operates mainly to cause impurity of the light, by reason of the fact that those rays which draw in toward the center earliest must naturally reach somewhat into the center of the spot, and coming, as they do, from the outer edge of the lens, they carry with them considerable color.

This, so far as I am able to determine, is the principal practical effect of spherical aberration. It amounts to a discoloration of the light, and hence a diminution of its brilliancy, though it may or may not be sufficient to be perceptible to the eye in individual cases.

Also spherical aberration, if excessive, will cause the spot at the aperture to consist of a series of circles of light instead of an evenly illuminated field, and as this plane is refocused at the screen, there will, if there is an absence of rays at the center, be a dark spot or "ghost," or if more of the rays are reaching the center of the spot than its edges, high lights will result. This is usually the result of the film cutting the beam of light too far from the actual mean focus of the crater, but there are, nevertheless, other conditions which result in high lights and shadows on the screen, and spherical aberration may result only in uneven illumination. There is practically no bad effect from spherical aberration through the stereopticon because the rays reach the slide before they are displaced, but chromatic aberration will show if the rays from the outer edges of the condenser pass through the slide.

Chromatic Aberration of the Condenser Beam.—In Plate 11, a crater is constructed by cutting an aperture in a piece of cardboard and placing a piece of ground glass behind it. Back of this is placed a 100 C. P. incandescent lamp. The crater and screen are placed at conjugate foci of the condensers. The screen corresponds to the aperture plate of the machine. A piece of cardboard pierced with a pinhole is placed as shown in Plate 11.

Plate 11, Figure 52.

The results as observed upon the screen, Plate 11, are: the crater is focused in full definition on the screen, but it is colored with the shades of the spectrum in the manner shown. Now it has been demonstrated by the Kinemacolor process that all the colors of the spectrum can be reduced to approximately two shades, viz: a reddish-orange and blueish-green, which for the sake of clearness we will call orange and green.

In Plate 11A are shown the same conditions described in connection with Fig. 1, except that the colors of the spectrum

have been reduced to the two primary shades, viz: orange and green. Notice that at the screen (or aperture) the colored rays combine and form white light.

Now, if the process shown in Plate 11A be continued, and a very large number of rays be drawn, using orange and green ink, the result will appear as shown in Plate 11B, in which it is observed that the beam is inclosed by an orange envelope, which is thickest toward the central part of the beam and comes to a point or disappears entirely at the aperture and the condenser. The beam has a core in the center which is composed of the violet, blue, and green shades of the spectrum. The white part of the beam is caused by the mixture of the two other primary shades, but *the mixture is not perfect at all positions.* At the section AA, Plate 11B, the white light is most pure, but as it approaches the position of section BB, the colors at the violet end of the spectrum commence to predominate, so that at section BB, the white zone has changed to a dirty purple. In view of this condition it is not difficult to understand why a ghost appears in the screen when the aperture is brought back too far toward point BB. When properly located all the colors of the beam finally combine at the aperture to form pure white light, and since it passes from aperture to objective, all light beyond the aperture is pure white. It is also noted that the light at section AA, Plate 11B, is pure white.

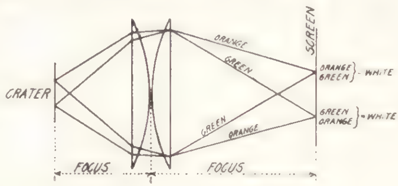


Plate 11A, Figure 53.

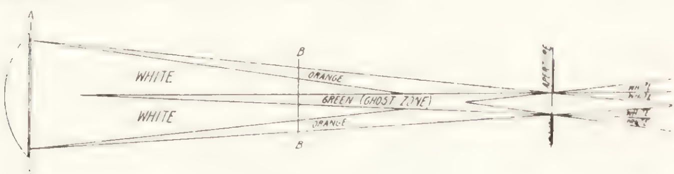


Plate 11B, Figure 54.

Now it must be remembered that the results shown in Plate 11B can only be approximately true, since all the colors of the spectrum, which are infinite in number, have been reduced to only two shades. Even if only seven colors had been used in the drawing, the straight lines in Plate 11B

Plate 11C, Figure 55.

would show as curves, and more closely resemble the true shape of the actual beam. Nevertheless, when a small screen is placed at different sections of the actual beam, the results show a very close agreement with the theories set forth.

In photographing the beam, only the white and green zones are actinic and show in the photograph, and by observing Plate 11B, it is seen that the theoretical shape of the combined white and green zones agrees very closely with the photograph. But even to the eye the beam has a curved shape, which is probably due to the existence of infra red at the outer edge of the orange envelope.

It is finally seen, as a further point in practical application, that *one of the important functions of having the crater in true focus at the aperture is to purify the light and avoid color effects.* The aperture may be placed a little forward of the focal plane, but should *never be behind it.*

Some of the practical effects of chromatic aberration are seen in Plate 11C. It will be observed that whereas the holes in the metal shield covering the condenser are of equal size the lower ray is much the stronger. This is partly due to its position, but also to a very considerable extent to color in the upper ray which reduces its actinic effect on the photographic plate.

Another important point in connection with the condenser is loss of light through poorly polished, unevenly finished surfaces, and through discoloration of the glass. Of late there have been those who have advocated the addition of yellow to the condenser lens glass, with the idea of mellowing light. With this I cannot agree. I think it is hardly necessary to enter into a discussion of the matter, and most emphatically advise operators to avoid the use of lenses containing discoloration of any kind. In selecting a condenser lens first examine its

surface, and, unless it presents a perfectly smooth, polished appearance, and evidence of having been ground to the true surface, reject the lens. In order to perform its function properly a lens must be a perfect segment of the surface of a sphere, and *this perfect shape can only be obtained by grinding*.

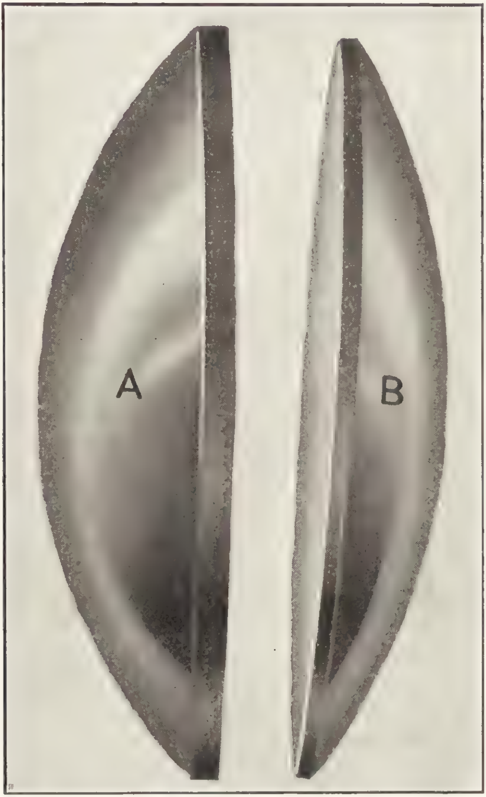


Plate 12, Figure 56.

It cannot, by any stretch of imagination, be had by merely polishing the surface of a molded lens.

Stop and consider the matter for a moment. In order to secure even approximately perfect results in illumination at the spot it is necessary that all light rays emanating

from any point on the crater and falling upon any point on the surface of the lens be so refracted that they will reach the same point in or on the spot.

Now this can only be accomplished by a perfectly true lens surface, and it therefore follows that if the surface of the lens be not perfectly true, some of the rays are going to be refracted properly and some are not, and this of necessity means loss in effectiveness. With this in view I would call the attention of theatre managers to the fact that the cheap, molded condenser lenses, having an uneven, wavy surface, may be cheap in *first cost, but are a mighty expensive article in the long run,* because of the fact that, since it takes current to produce light, and you have to buy the current, anything which makes for ineffectiveness in illumination means a waste of current, hence you are simply saving a small sum of money in the original cost when you buy a cheap condenser lens, and *are paying out money every* minute you run for current to produce light which the cheap lens is *wasting.*

Also *reject any lens which does not measure exactly 4½ inches in diameter and which has an excessively thick edge.* Condenser lenses should be exactly 4½ inches in diameter, and should come down to an edge but little if any thicker than one-sixteenth of an inch. A thick edge means unnecessary glass; therefore unnecessary absorption of light. In Plate 12 A shows the wrong and B the right lens edge. It is important that the edges of condenser lenses be of standard thickness, and that their diameters be exactly 4½ inches, because not only is excessive glass wasteful (it is impossible for manufacturing reasons to bring the edge right down to a thin edge at a 4½ inch diameter) but with edges of varying thickness it is impossible to make the lenses fit properly in many of the machine lens holders; also any change in diameter alters the fit of the lens in the holder, and these *variations will render it practically impossible for the operator to properly line up his lens system.* I would suggest that operators pay careful attention to this matter because lens manufacturers seem to think that "near or about" is good enough, both in diameters and lens edge thickness. They will only change that attitude and come down to a fixed standard when a large number of kicks are registered by purchasers. I have pointed out the reasons why diameters and lens edge thickness should be absolutely standard. I think you will have no trouble in recognizing the fact that these reasons are sound. It is now up to you to compel lens manufacturers to produce a standard article, and I

suggest that you insist on an exact 4½ inch diameter and a lens edge thickness exactly one-sixteenth of an inch. It is quite true that to thus standardize lenses might add somewhat to their cost, but even so, it will be money saved in the end, no matter from what angle the proposition be viewed.

In selecting your condensing lens, first examine its surface, and if it is not perfectly smooth and highly polished it is not a good lens. Next look through the lens *edgewise*, and if it does not show clear (has any trace of color when looked through that way) *reject it.* It is not a good lens.

If you have any doubt whatever as to the inadvisability of using lenses containing color, either purple, greenish or yellow, break a clear white condensing lens in half; also break a lens containing discoloration in half, put these two halves in as the front lens of your condenser combination, being certain the rear lens contains no color, and project the clear light on the screen through the stereopticon lens. I think the appearance of the screen will satisfy you thoroughly as to the advisability of rejecting any lenses containing any color whatever. This experiment should *only* be tried through the stereo lens, with which the two halves can be focused at the screen.

In a camera the lens receives rays directly from an object and delivers them directly to the screen (plate).

In the projector there are two absolutely separate lens systems, one of which receives its rays from the other, and one of our problems is to so join these two systems that the film picture will not only receive a *maximum of illumination,* but also that that *illumination shall be evenly distributed over the entire area of the photograph*, and that the second or objective system be enabled to pick up the light rays delivered to it by the first or condenser system, with the least possible amount of loss.

Now these various propositions look reasonably simple, but there are, in fact, some very intricate problems involved. With relation to the condenser system, there is one point on which we have very little accurate data, viz.: the exact diameter of the crater for a given amperage. Until this matter is accurately determined our efforts in that direction can only be approximately correct, and possibly there may always be some differences in this item since doubtless different carbons will slightly alter crater size for a given amperage.

One exceedingly important point, which must be borne carefully in mind, is that *when the source of illumination is greater*

than a point the light ray from the condenser can never be brought to a point, for example: Assuming the crater to be an object, and the spot on the aperture an image (which is the exact condition), if the crater be 4 inches from the apex of the curved surface of the back condenser, and the spot on the aperture 16 inches from the apex of the curved surface of the front condenser, then the diameter of the spot on the aperture will be four times the diameter of the crater, of which the spot is an image, and the spot will be the narrowest part of the condenser beam, since at this point the beam will begin to diverge, therefore we cannot consider the condenser beam as coming to a point further on, as it has always been supposed to do.

Not only have we discovered the fact that there is a direct ratio between the diameter of the crater and the diameter of the spot on the cooling plate, but we have also found that in order to obtain the most even illumination of the entire aperture it is necessary that the crater be "in focus" at the aperture of the machine, or in other words, that the crater and spot be at the respective points of conjugate foci of the condenser lens.

Now in order to understand this some of you must do a little studying. Take a condenser lens and hold it near the wall of a room, opposite an open window, and you will find that with the lens at a certain distance from the wall you get a fairly good image or picture of the scene out of doors on the wall. This means that the lens is at a distance from the wall equal to its focal length, or, in other words, *in a position where rays emanating from a point on an object are brought to a focus in the image, not* where the light beam, as a whole, is brought to a point, which it never is. Move the lens further from the wall and the ray increases in size and is quickly lost.

Some may dispute this, and cite the burning glass in proof. Well, the point to which the burning glass *apparently* brings the rays is not a point at all, but merely an exceedingly small image of the sun.

Now, taking the condenser as a whole, the crater of the carbon takes the place of the scene out of doors, and the aperture of the machine the place of the wall. Of course the image is formed much further away than was the case with the lens held near the wall, but this is by reason of the fact that the crater (object) is close to the lens, whereas the out-of-door scene was far away. If a single lens were used, instead of a double one, these distances would again be altered.

And now the question comes: *When is the crater in focus at the aperture?* This is a somewhat complicated proposition, in which we must take into consideration the known fact that spherical aberration exists in the condenser system, and the further fact that the crater does not set parallel to either the condensing lens or the film; therefore, due to the latter equation, there is bound to be precisely the same effect at the spot as there is when the machine sets at an angle to the screen. In other words, since the surface of the crater is not parallel to the lens the whole crater cannot possibly be put in sharp focus at the aperture, or anywhere else. We must therefore adopt a "mean focus point" or point of actual mean focus, since we cannot expect to get a sharp focus of the entire crater for reasons already pointed out. The point of actual focus must, due to spherical aberration, be beyond the plane where the rays from the outer edges of the spot would naturally focus, they being focused nearer the lens than the rays forming the center of the spot; therefore the plane of actual mean focus will to some extent have the appearance of back focus at the cooling plate. In fact, the focus of the crater may be assumed to occupy any position between the circle of least confusion, which may be recognized as a round spot with reasonably sharply defined edges, and a plane a few inches in front of the circle of least confusion, which latter may be recognized as a white spot surrounded by a bright blue outline. This blue spot consists of the aberrated rays on the back focus, the white spot in the center of the haze being the image of the crater.

The ordinary practice of the operator is to carry a sharp, round spot at the cooling plate, rather than the actual focus of the crater, and so long as he can maintain this spot small enough, and still keep his arc near enough to the back condenser to give good illumination, all is well—provided he can also maintain a distance sufficiently great between the condenser and aperture to prevent the rays in front of the aperture from diverging beyond the limits of the objective lens. See Plate 8.

When the distance between the condensers and film becomes too great to maintain a suitable size focused spot at the aperture and still keep the arc near enough to the condenser, the only alternative is to focus the actual image of the crater, which is surrounded by a blue haze, at the aperture, and in order to do this it is necessary to utilize the whole length of the machine table, and also the shortest focal length condensers usually carried in stock, viz: two

6½ inch, in order that the white center be sufficiently magnified to fully cover the aperture. The spot produced by this arrangement will not look very picturesque on the cooling plate, but *will give very superior results on the screen.* If the amperage be very heavy it may be necessary to use one 6½ and one 7½ condenser, or if very light then one 5½ and one 6½ will be best. In this we assume the limit of the machine table to be such that approximately twenty-two inches can be had between the condensers and aperture.

Note.—You cannot have too great a distance between the condensers and aperture, provided you keep your arc near enough to the back condenser.

The tables given in this article merely provide the minimum, and the condensers therein named are for working with the spot at the plane of least confusion only. I would suggest that any condition calling for greater focal length condensers than 6½ and 7½ will be better taken care of by using the spot with the blue haze and shorter condensers and the limit of distance between the condenser and film.

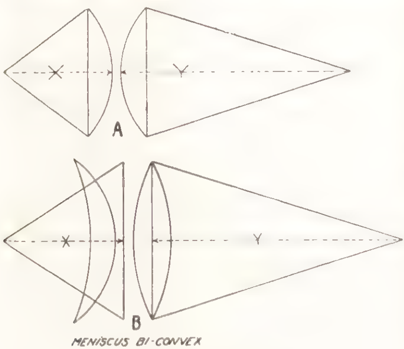


Plate 13, Figure 57.

Remember this: The spot itself is actually *an image or picture* of the crater. It therefore follows that any attempt to use both craters with A. C. will set up difficulty, since it will, in the very nature of things, be extremely difficult, if not impossible, to get their images properly superimposed upon each other.

Some operators have got splendid results from meniscus-bi-convex condensers, whereas others have reported no perceptible advantage in their use. It is all a matter of local conditions. Operators who have difficulty in getting their arc near enough to the condenser are the ones who will get best results with the meniscus-convex combination, by reason of the fact that they gain at least ¼ of an inch between the arc and the condenser, owing to the fact that the planes from which the conjugate foci are measured are changed—that is to say, they are not the same with the meniscus-bi-convex as

they are with two plano-convex (see Plate 13). This is owing to the introduction of two more curved surfaces. The result is less enlargement of the crater. On the other hand, the operator who can get near the condenser with his arc and still have a small spot will find but little benefit in the use of the meniscus-bi-convex set, provided the meniscus-bi-convex and plano-convex lenses be of the same quality, except in reduction of spherical aberration.

The theory upon which the action of light rays through the projector system, as set forth in this article, is based, is a difficult matter to explain in such way that the reader or student will grasp the idea. Light action is one of the most difficult things imaginable to describe intelligently by reason of the fact that in drawing diagrams representing light action one is limited to the examination of the action of one, two or possibly a dozen rays out of literally millions and, as a general rule, the student has difficulty in considering the single ray or the few rays shown in the diagram as being representative of the action of countless numbers of rays which accompany it but are not shown.

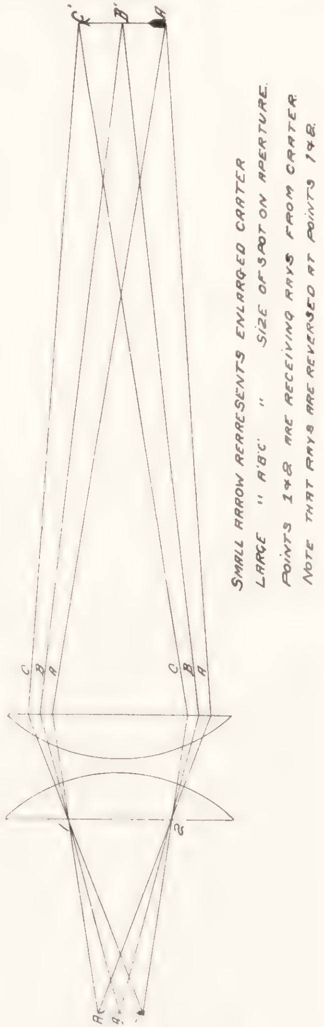


Plate 14, Figure 58.

In this connection, as a digression, it might be interesting to know that scientists tell us that a bundle of thirty-six

light rays will have approximately the same area as that of a single human hair.

Beginning with a fact with which all are more or less familiar, viz.: that from each point in a light source rays radiate in all directions (in the case of a projection arc light crater it would not be literally in "all directions," but in all directions over an area covering what would be practically equal to one-half the surface of a globe) until they meet with some obstruction. After leaving the crater the first obstruction encountered is the condensing lens through which the rays must pass. This gives us countless numbers of cones of light as A-1-2, B-1-2, C-1-2, Plate 14, each cone having its apex at a point in the crater, and its base on the surface of the condensing lens. The sum of these cones represents the total light passing through the condenser. Each one of these cones is made up of diverging rays exclusively, up to the rear surface of the condensing lens. With this I believe we all will agree, and thus endeth the first part.

But when we come to examine into their action beyond the rear surface of the condensing lens we find that the foregoing does not fully elucidate or make clear the entire problem.

First: From each point on the crater we have rays entering every minute pinpoint on the surface of the condenser, therefore through each point of the condenser we have passing a cone of *converging* rays, each cone carrying a complete image of the crater, as per A-C-2, A-C-1, so that we are also entirely correct when we consider the total light passing from the crater through the condenser as consisting of countless numbers of cones of *converging* rays having their apex at a point on the condenser at 1-2, Plate 14. It will thus be seen that while we do not actually have two sets of rays we do have a double light action. It may very reasonably be asked: "If the first part includes the total rays passing from the crater through the condenser, and the second part merely does the same thing in a different way, why bother with the second part at all when the action first described is more generally understood?"

The reason for analyzing the action of light rays completely and describing the second part is because it gives us a clearer understanding of what follows.

Now having in mind one of the cones A-C-1, or A-C-2, Plate 14, it will be readily seen that rays A-1 and C-1 meeting at a point on the condenser will, even though refracted,

cross at the plane of the condenser. This can easily be proven by using a refractometer. It therefore follows that as the total rays entering and passing through the condenser from the crater may be considered as consisting of countless cones having their apex at a point on the condenser, the crossing point or reversal of the image must, in the very nature of things, take place at the rear plane of the rear condenser and at no other place. Undoubtedly the rays do cross each other before reaching the condenser plane, but only when on their way to and from a point which is receiving a complete image of the crater.

This action is perhaps made most clearly intelligible, and may be best adapted to use in this article by considering cone A-1-2, cone B-1-2, cone C-1-2, cone A-B-1, A-B-2 and B-C-2 (remembering that these are but representative of

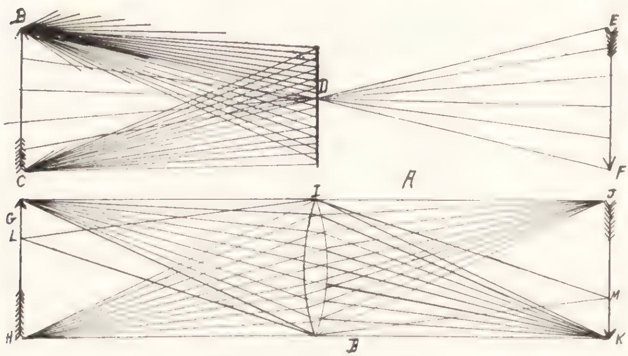


Plate 15, Figure 59.

millions of other similar cones at other pinpoints on the crater and condenser) as being two sets of rays. Please understand that we do not mean by this that there actually are two sets of rays, but merely use that term as a convenient medium through which to describe certain action of the light which really is the same group of rays acting in two different ways.

Theory of double action may perhaps be made more understandable by means of diagram, Plate 15, which is a diagrammatic representation of pinhole photography.

In Plate 15, at A, we see a diagrammatic representation of pinhole photography, in which rays by the millions go in every direction from every point of arrow B-C, *but only those*

rays striking pinhole D can pass through and form an image on the screen at E-F. That is the idea we had in mind in saying that one set of rays projected the whole crater. To get the point of view, *you must consider each minute point on the back plane of the condenser as being a pinhole,* and as a matter of fact it does act in exactly that way, therefore each minute pinhole point of the condenser will receive one ray from each pinpoint of the crater and will therefore project an image of the crater, *as a whole,* to the aperture of the machine. This same thing is shown photographically in Plate 16, in which

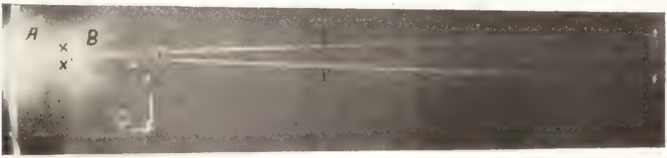


Plate 16, Figure 60.

A is the machine aperture, covered by a plate in which are two pinholes, and B the back factor of an objective, covered with a plate containing one pinhole. The action is that rays from the lower half of upper cone X pass through as ray Y, whereas from the upper half of cone X pass through as ray Y. The photo is a poor one, as it is extremely difficult to get a good picture of such weak rays. A comparison will reveal the fact that the action in A, Plate 15 and in Plate 16, is identical.

The second set of rays, viz.: those emanating from a point on the crater, represented by cones A 1-2, and B 1-2, and C 1-2, Plate 14, project to the same aperture, in converging lines, rays from every infinitesimal portion of the crater, and that is the real explanation.

The foregoing theory is not altogether coincided in by some, but the fact, nevertheless, remains that it is the only one by means of which we can explain one phenomenon, viz.: why the beam of light is round as it emerges from the objective, and continues so for a distance varying with the focal length of the lens, and thence to the screen is rectangular. And now comes the difficult part to explain.

In Plate 14 we see a diagrammatic representation of Griffiths' theory, as applied to the condenser system. In Plate 16 we see, in photography, precisely the same thing as applied to

the objective lens. Always bear in mind one fact, viz.: *the optical action of the objective lens and the optical action of the condensing lens is in every respect identical.*

Now to follow this matter through we will consider Plate 17, which is a photographic representation of light ray action in an objective lens, in which X is a shield containing a standard machine aperture, covered by a brass plate containing two pinholes. Y is a standard projection lens, with one-half of its barrel cut away, 1 and 2 being respectively the back and front factors of the lens, though 2 is hidden behind its container. This photograph is made with the aperture and the lens in actually working position, and with the light projected through the condenser in the ordinary way, under actual operating conditions. You will observe that the light coming through the upper pinhole, Plate 17, diverges into a cone, which corresponds to cone A, 1-2, Plate 14. This cone covers very nearly the full aperture of the lens. The light passing through the lower pinhole does exactly the same thing, and the two cones begin to intermingle at L, and from there on to the lens a small central light pyramid is shown, the upper half of which is the upper edge of the lower pinhole cone, and its lower edge the lower edge of the upper pinhole cone. Beyond the back factor of the lens, between the two lens factors, you can easily trace the action. And it is made clear in this photograph that *the bend which starts the final crossing or transposition of the rays takes place at the first or back surface of the first or back combination of the objective,* even as it takes place at the back surface of the rear lens, Plate 14. The action, as between the diagram, **Plate**

Plate 17. Figure 61.

14, and the photograph, Plate 17, is precisely identical in every way. As the light leaves the front end of the objective you will observe that rays of the two are not entirely intermingled but that the mingling can be traced clear through by the brighter light. This intermingling condition continues out to where the cone projected by the upper pinhole has passed down sufficiently to entirely leave the cone thrown from the lower pinhole, which latter is at the same time passing on its way to the screen. The action of these two cones of rays are typical of those passing through every pin-point of the film picture.

Each individual point of the film acts as does the pin hole, and in sending a cone of rays forward exactly like those shown at L, Plate 17, and, since each of the rays contained in each of these cones carries an image of the point of the film through which it passed, it follows that all these rays must be refocused at the screen; it also follows that the actual crossing is as shown in the photograph. I believe this photograph will be of vast interest to operators.

And now let us apply the theory of the "two sets of rays," and see how it works in practice. Operators have long been puzzled as to why the spot on the revolving shutter is round when the shutter is close to the lens, whereas a little further ahead, toward the screen, it becomes rectangular. The two-ray idea is the only theory that seems to account for this, and it is to some extent this fact which has convinced me of its absolutely correctness.

First fix the following firmly in your mind. There are two complete but entirely separate optical systems in the projection machine lens system, which are, in effect, combined into one. Remember that the optical action of the condenser and objective is *precisely the same.* In fact the condenser is a crude, extremely imperfect objective lens; therefore, we have in effect two objective lenses joined together, and the object is *to so join these two systems together that there will be a maximum of illumination of the object to be projected,* and the rays directed against and through this object by the first system must be so joined to the second system that there will be a minimum loss of light, and no opposition created by the refractive power of one system as against the refractive power of the other system. The second system (the objective) picks up the rays delivered at the aperture by the first system (the condenser) exactly as they are delivered by it, therefore when the distance of the crater from the rear condensing lens is so proportioned with relation to the distance

from the back plane of the rear condensing lens to the aperture that the image of the light source (the crater) is in exact focus at the aperture, and the spot is of such size that the circle of clear, white light covers the aperture completely, with sufficient margin to enable the operator to maintain a clear field, then the plane of light at the aperture, where the objective picks up its rays, contains the maximum illumination, and, moreover, that illumination is evenly distributed over the entire area of the aperture.

And now let us see how Griffiths' two-sets-of-rays theory squares up with what is actually observed to take place in practice. It has always been somewhat of a puzzle to operators why the rays emerging from the objective lens do not immediately diverge straight to the screen, instead of converging a little and then diverging (this is only noticeable when the condenser image is smaller than the aperture of the lens), and also that they have a more or less round form until they reach the narrow part of the beam, from which plane the shape becomes rectangular. For the sake of convenience we will refer to that set of rays coming from a point of the crater as the *crater set*, and those coming from the whole of the crater to a point of the condenser as the *condenser set*.

The first point to determine is, in what manner do these two sets of rays reach the objective lens, after which we may compare the result that should occur with these two sets of rays with what we actually observe in practice. It has already been said that the condensers act precisely as would a crude objective lens, therefore, the crater set, being the diverging set of rays emanating from a point of the crater, must meet again at a point of the crater image (spot of the aperture), and as the film is at this plane, these rays pass through a point of the film cross and again diverge to the objective lens. *Thus our crater set reaches the objective from a point of the film,* and their shape will correspond to the shape of the aperture of the condenser. If a slide carrier is used the ray will, in the very nature of things, be rectangular, but if the condenser opening be unobstructed the ray will, of course, be round.

Now, let us trace the condenser set from the crater to the objective lens. It has already been explained that each point of the condenser is receiving a ray from every point of the crater, so that through each point of the condenser a complete image of the crater is being projected, and as these rays diverge from that point to every part of the crater image which they carry, they must carry a full film image to the objective lens, arriving at the same as a rectangle somewhat

larger than the aperture, therefore, the "condenser set" of rays arrive at the objective carrying a full film image. It therefore follows that if a slide carrier be used, both sets of rays will arrive at the objective lens with an over-all rectangular outline, one, the crater set, having the shape of the slide carrier, and the other, the condenser set, having the shape of the film aperture, the condenser set carrying a full film image, and the crater set carrying the image of a point of the film. Now these two sets of rays, one emanating, so far as concerns the objective, from a point of the film and the other from a point of the condenser, have a different angle of divergence, and must therefore be brought to a focus at two different planes. Those coming from a point of the film, and, incidentally, forming the crater image, must focus at the film image, viz: at the screen, and those coming from a point of the condenser must focus at the point of the condenser image, and as the angle of divergence of the condenser set of rays is much narrower than the angle of the divergence of the crater set, it follows that these rays will meet (focus) much nearer the lens than the other set. In fact their focusing point will be identical with the position of a photographic plate in a camera when taking a picture of an object as far away from the camera lens as the condenser is from the objective, the camera having a lens similar to the objective. And this is exactly where we do find the condenser image, viz: a little further in front of the objective lens than the back focus at which it is working. The existence of the condenser image at this position proves that the condenser set of rays, the existence of which has met with so much opposition, is really the key to the whole problem, because the condenser set of rays carry the full image of the film, and as they come from a point of the condenser *the film image is reversed at the condenser image.*

But, I hear some one ask, if both sets arrive at the objective rectangular in form when the slide carrier is used, why do they emerge from the objective round in form? A bundle of rays from a point of the center of the condenser will arrive at the objective lens as a rectangular a little larger than the aperture, its style varying with the B. F. of the lens, but a bundle from a point near the edge of the condenser will arrive at the lens in a different location, so that only a part of the image from this point enters the objective. The sum total of all the rectangles from every point of the condenser is a rectangle much larger than the aperture of the lens, the result is that the beam, as a whole, is trimmed into a round shape. But, you may ask, if the rectangle has its corner rounded off, why

does it show rectangular again after passing the condenser image? You will observe that the rectangle from one point of the condenser is smaller than the rectangle representing the whole beam of light, so that only one corner is clipped off by the lens, and while this corner is on the outside up to the condenser image, thereafter it is on the inside, and as there is a pyramid from each point of the condenser image, the defective corner is hidden by other pyramids from more central portions of the condensers which are projecting perfect pyramids.

This trimming process is also applied to the crater set of rays, whether they are from a rectangular slide carrier or a round condenser. No matter what shape they are, each ray passes through the condenser image at a point corresponding to that through which it passed through the condenser; therefore the two sets of rays emerge from the lens converging, the *crater set* carrying an image of a point of the film meeting at a point of the film image at the screen, while the *condenser set* meets at a point of the condenser image, and then diverge to the full screen. This is why you can almost completely cut the beam of light at the condenser image with the shutter, and still have a full image of the aperture at the screen. So that it will be seen that that much mooted question which has been cussed and discussed for lo these many years: "Where do the light rays cross?" is answered by saying that they are crossed at the image of the condenser when projecting moving pictures, and in the center of the lens when the stereo lens is used, and therefore the old theory holding that the light rays crossed in the center of the lens *still is true when speaking of lantern slide projection.* The next question is, if the film image is crossed and reversed at the condenser image: why is the stereo slide image not crossed there? The answer is: The film photograph is being projected from the *crater image plane,* whereas the stereo slide photograph is being projected from the condenser plane, with the result that the rays from one point of the source carry a full slide image which crosses where the rays meet, viz: the image of the source, or crater, and as the center of the stereo lens is the best location for this plane, it is quite true that the rays cross in the center of the lens when projecting stereo slides.

Matching the Lenses.—The following tables have been worked out as a final result of the foregoing theories. By their use the operator will be enabled to match up his lens system accurately and with as great precision as the limitations of present day apparatus will allow.

	5½" & 6½" CONDENSERS.					6½ & 6½"				6½ & 7½"			7½" & 7½"		
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
15/16												1"	1"	1"	1"
1"									1"	1"	1"	1.201	1.22	1.23	1.235
1 1/16							1"	1"	1.172	1.187	1.2	1.414	1.44	1.46	1.470
1 1/8				1"	1"	1"	1.157	1.167	1.344	1.374	1.4	1.621	1.66	1.69	1.705
1 3/16			1"	1.118	1.133	1.143	1.314	1.334	1.516	1.561	1.6	1.828	1.85	1.42	1.945
1 1/4			1.118	1.230	1.266	1.282	1.471	1.501	1.688	1.741	1.8	2.035	2.10	2.15	2.175
1 5/16		1"	1.216	1.354	1.399	[illegible]	1.528	1.668	1.860	1.935	2.	2.243	2.32	2.38	2.41
1 3/8	1"	1.099	1.324	1.472	1.532	1.672	1.785	1.835	2.032	2.122	2.2	2.441	2.54	2.61	2.69
1 7/16	1.086	1.198	1.432	1.590	1.665	1.715	1.946	2.002	2.204	2.309	2.4	2.656	2.76	2.84	2.88
1 1/2	1.173	1.297	1.540	1.708	1.798	1.858	2.094	2.169	2.376	2.496	2.6	2.855	2.98	3.07	3.11
1 9/16	1.259	1.396	1.648	1.826	1.931	2.001	2.256	2.336	2.548	2.683	2.8	3.060	3.20	3.30	3.35
1 5/8	1.346	1.495	1.756	1.944	2.067	2.144	2.413	2.503	2.720	2.870	3.	3.267	3.42	3.53	3.58
1 11/16	1.432	1.594	1.964	2.062	2.197	2.281	2.570	2.670	2.892	3.057	3.2	3.474	3.64	3.76	3.82
1 3/4	1.519	1.693	2.072	2.180	2.330	2.430	2.727	2.837	3.064	3.244	3.4	3.681	3.86	3.99	4.05
1 13/16	1.605	1.792	2.180	2.298	2.465	2.573	2.884	3.004	3.236	3.431	3.6	3.888	4.08	4.22	4.29
1 7/8	1.692	1.891	2.288	2.416	2.596	2.716	3.041	3.171	3.408	3.618	3.8	4.195	4.30	4.45	4.52
1 15/16	1.778	1.990	2.396	2.534	2.729	2.859	3.198	3.338	3.580	3.805	4.	4.402	4.52	4.68	4.76
2"	1.865	2.089	2.504	2.652	2.862	3.002	3.355	3.505	3.732	3.992	4.2	4.609	4.74	4.91	4.99
2 1/16	1.951	2.188	2.612	2.770	2.995	3.145	3.512	3.672	3.924	4.279	4.4	4.816	4.96	5.14	5.23
2 1/8	2.038	2.287	2.720	2.888	3.128	3.288	3.669	3.839	4.096	4.466	4.6	5.023	5.18	5.37	5.46
2 3/16	2.124	2.384	2.828	3.006	3.261	3.431	3.826	4.006	4.269	4.655	4.8	5.230	5.40	5.60	5.70
2 1/4	2.211	2.486	2.936	3.124	3.394	3.574	3.983	4.173	4.440	4.840	5	5.437	5.62	5.83	6.93
2 5/16	2.277	2.584	3.044	3.242	3.527	3.717	4.140	4.340	4.612	5.027	5.2	5.644	5.84	6.06	6.17
2 3/8	2.383	2.683	3.152	3.360	3.660	3.860	4.297	4.507	4.784	5.214	5.4	5.851	6.06	6.29	6.40
2 7/16	2.470	2.782	3.260	3.478	3.793	4.003	4.454	4.674	4.956	5.401	5.6	6.058	6.28	6.52	6.64
2 1/2	2.556	2.881	3.368	3.596	3.926	4.146	4.611	4.841	5.128	5.588	5.8	6.263	6.60	6.75	6.87
2 9/16	2.643	2.980	3.476	3.714	4.059	4.254	4.768	5.009	5.300	5.775	6	6.412	6.72	6.98	7.11
2 5/8	2.727	3.534	3.579	3.832	4.192	4.432	4.925	5.176	5.472	5.962	6.2	6.677	6.94	7.21	7.34
2 11/16	2.816	3.178	3.692	3.950	4.325	4.575	5.082	5.343	5.649	6.149	6.4	6.886	7.16	7.44	7.58
2 3/4	2.902	3.277	3.800	4.068	4.458	4.658	5.231	5.510	5.816	6.336	6.6	7.093	7.38	7.67	7.81
2 13/16	2.989	3.376	3.908	4.186	4.591	4.801	5.396	5.677	5.988	6.523	6.8	7.300	7.60	7.90	8.06
2 7/8	3.075	3.475	4.016	4.304	4.724	4.944	5.553	5.844	6.160	6.710	7	7.507	7.82	8.13	8.28
2 15/16	3.162	3.574	4.124	4.422	4.857	5.087	5.710	6.011	6.332	6.897	7.2	7.714	8.04	8.36	8.52
3"	3.248	3.673	4.232	4.540	4.990	5.230	5.867	6.178	6.504	7.084	7.4	7.921	8.26	8.59	8.75

APERTURE OF OBJECTIVE LENS

DISTANCE BETWEEN CENTER OF CONDENSERS AND APERTURE PLATE.

Table 1, Figure 62.

Decimal Equivalent.—1/16 = .0625; 1/8 = .125; 3/16 = .1875; 1/4 = .25; 5/16 = .3125; 3/8 = .375; 7/16 = .4375; 1/2 = .5; 9/16 = .5625; 5/8 = .625; 11/16 = .6875; 3/4 = .75; 13/16 = .8125; 7/8 = .875; 15/16 = .9375.

Table 1 is what might be termed the "angle table." It represents the tabulated results of what is shown in the diagram in Fig. 4. In order to apply this table proceed as follows:

First measure the diameter of the opening of the objective lens. Next, with the picture in exact focus on the screen, stick a rule through the aperture of the machine and place it against the back surface of the back combination of the objective lens, and measure the exact distance from the lens to the film, or, in other words, from the lens to the surface of the film track on the aperture. This will give you the exact back focus of the lens at the position in which it works. This is of the greatest importance because any given lens may work in different positions under different circumstances. Having found the measurement of the diameter of your objective, and its back focus when in working position, proceed as follows:

In the extreme right-hand column find the number most nearly corresponding to the back focus at which your lens is working. Opposite this number, in the extreme left-hand column you will find the smallest lens diameter permissible at that back focus, and at the top of the right-hand column we see that the condensers must be two "7½s," with 22 inches between the apex of the front lens and the film. For example: Suppose the B. F. to be 4½ and the lens diameter 1⅝ inches. At the sixteenth line down we find 4.52 (practically 4½) in the right-hand column, and opposite, in the left-hand column, 1⅞. We therefore see that 1⅞ is the least permissible lens diameter, and that our lens is unsuitable to the work in hand. Looking at the top of the right-hand column we see that with the 1⅞-inch lens we must have two 7½ condensing lenses with not less than 22 inches between the apex of the front lens and the film. This is the extreme condition. Looking in the third column from the right, however, one line further down we again find 4.52 and discover that with a lens 1 15/16 inches in diameter we may use two inches less between condenser and film, though two 7½ lenses are still required. Again looking, we find 4.60 in the fourth, 4.6 in the fifth and so on over to the twelfth column, where we find 4.540 in the bottom row and see that with a lens 3 inches in diameter we could use one 5½ and one 6½ condenser, with 11 inches from apex of front lens to film—the extreme condition in the other direction.

Table 2 shows relative distances of conjugate foci and amount of enlargement of the image of the object, the object being the crater or source of light and the image the spot on the aperture.

Diagram A, Plate 13, shows the points from which the distances are measured with plano convex combinations.

Diagram B, Plate 13, shows the points from which the distances are measured with a meniscus-bi-convex combination. With the plano convex combination X equals the distance from the crater to the curved surface of the back condenser,

and Y equals the distance from the curved surface of the front condenser to the aperture.

With the meniscus-bi-convex combination X equals the distance from the crater to a point ⅛ of an inch in front of the convex face of the back condenser, and Y is equal to the distance from the center of the bi-convex condenser to the aperture.

The essential difference between the meniscus-bi-convex and the plano convex is that there is less enlargement of the spot on the aperture with the former when the E F is the same in both cases.

The enlargement with both sets is equal to distance Y divided by distance X, both in inches.

When meniscus-bi-convex condensers are substituted for plano convex we increase X by ⅛ of an inch and decrease Y by the thickness of a plano lens, because the center of the bi-convex occupies the same position as the plane of the plano convex.

Example.—Plano convex R = 4, Y = 16, therefore enlargement equals 16 ÷ 4 = 4 times, so that the spot will be 4 times the diameter of the crater. Meniscus-bi-convex X = 4⅛ and Y = 15, therefore the enlargement equals 15 ÷ 4⅛ = 3.83 times.

The necessary enlargement of the crater will depend on the number of amperes we use, so, knowing the distance Y, which is the distance the objective calls for between the condenser and the aperture, see table 1, we look for that distance under the enlargement head we require, but we must choose it in conjunction with X, remembering that X is the distance between the crater and the condenser, plus thickness of the lens, and that with the meniscus-bi-convex the enlargement will be less than what the table calls for, we see the figures we need will be those giving slightly a greater enlargement. If with plano convex we need a four time enlargement, with meniscus-bi-convex we could choose about a 4½ time enlargement. An examination of the tables

Condensers		Equal	2	3	4	5	6 ← Enlargement of Crater	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches
5½-6½	EF 2.9	5.8	435	386	36	348	338	X
		58	87	116	145	174	203	Y
6½-6½	EF 3.25	650	487	433	406	39	379	X
		650	975	13	1625	195	2275	Y
6½-7½	EF 3.48	696	522	464	435	417	406	X
		696	1044	1392	1740	2088	2436	Y
7½-7½	EF 3.75	75	562	5	4.69	45	433	X
		75	1125	15	1875	225	30	Y

Table 2, Figure 63.

will make this clear, and will show the advantage of using the meniscus-bi-convex set where it is difficult to obtain a spot small enough and still keep the arc at proper distance from the lens.

Another important point which has been determined is that in thousands of instances objective lenses now in use are not large enough in diameter.

With reference to the difficulties that may be encountered with the large aperture lens and the revolving shutter the following facts will be of interest:

The diameter of the beam of light at its narrowest part in front of the objective is in proportion to the distances between the condenser and aperture and the equivalent focus of the objective lens. That while it is the equivalent focus of the objective lens that determines where the crossing point of the rays in front of the objective will be, changing the distance between condensers and aperture changes the diameter of the narrowest part of the beam considerably and also causes a small change in the position of the narrowest part, which is the image of the condenser aperture. Increasing the distance between the condensers and aperture decreases the thickness of the beam at its narrowest part, and vice versa. So that increasing the diameter of the objective lens, and at the same time shortening the distance between condensers and aperture, operates to increase the diameter of the beam at its narrowest point; but if we increase the diameter of the objective lens without altering other conditions, the width of the beam at its narrowest point does not increase.

The crossing point of the light beam will hardly be discernible when the distance between condenser and aperture is short, owing to the fact that the image of the condenser aperture is further from the lens, and consequently larger, so that rays to this image do not have to converge, therefore the whole beam of light will appear to diverge from the lens.

In this connection it is interesting to note that increasing the distance between condensers and aperture may be used to eliminate travel ghost when the shutter blade is too narrow. The effect of withdrawing the lamphouse from the machine head has the same effect on the narrowest part of the beam of light as withdrawing the arc from the condenser has on the spot at the aperture.

In conclusion: Until such times as objective lenses and condensers are brought up to our requirements the following points should be observed: Always have the crater as near

as possible to the condensers—say between 3½ and 2½ inches, according to the amperage used, and always have the greatest possible distance between the condensers and aperture.

These two conditions in some cases conflict with present apparatus, therefore, it may be necessary to compromise between the two. But the compromise means loss in efficiency.

For convenience in the use of these tables the decimal equivalents for fractions are given. I believe the foregoing is reasonably clear—at least sufficiently so that the table can be readily applied by the operator.

Caution.—*In measuring the back focus of your lens be very careful that the end of your rule is PERFECTLY CLEAN, because otherwise it might leave a faint mark on the lens which would injure the definition of the picture on the screen.*

These tables do not appear very imposing, but you may take it from me they represent a vast amount of labor. I would not presume to claim perfection for them. In fact I think it quite possible they may be subject to improvement, but I do think they are the first really intelligent step in advance, in this particular direction, since the projection optical system was first evolved.

I believe a great many operators are now losing a large percentage of their light by reason of the fact that the diameter of their objective lens is too small for the condition under which it works. You will observe, too, that the smaller the diameter of the lens the farther away must the condenser be from the aperture, and Table 2 will show you that

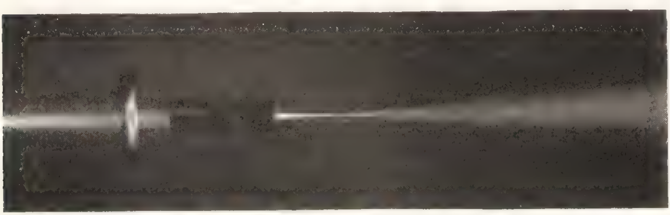


Plate 18, Figure 63A.

under certain conditions the arc will be a great distance from the lens, thus involving excessive light loss. If you are obliged to locate the arc more than 3½ inches from the condenser in order to have a normal spot 1½ inches in diam-

eter, and still meet the conditions as per Table 1, you may instantly conclude that something is wrong, and that something most likely is one of two things, viz.: wrong condenser focal length or wrong diameter of the objective. Table 2 gives objectives up to 3 inches. Personally, I believe 2½ should be the limit.

Plate 18 is a photograph of light rays obtained by placing a metal diaphragm, containing in its center a hole one-quarter inch in diameter, against the front condenser, so that the hole comes opposite to its center. You will observe the light ray comes down to a fine point, and *the least diameter of the ray indicates the point at which the shutter should be set.* In very long and very short focal length lenses it is impossible to set the shutter at this point because in one instance it comes inside the hood of the lens barrel and in the other it is so far away that the shutter cannot reach it. This point may be found by using a plate as in the foregoing and with the machine gate open blow smoke in the ray in front of the objective, whereupon the correct or at least the best position for the shutter can be plainly seen.

Some men could learn if they didn't already know it all

Projection

PROJECTION is a term which, taken as a whole, involves many things. As a matter of fact, broadly speaking, we may say that the whole motion picture industry rests to a large extent on projection. I base this statement on the fact that, no matter how perfect may be the work of the producer, no matter how beautiful may be the decoration of the theatre, or how excellent its appointments, or how courteous its attendants, or how perfect its music, still, if the projection of the picture itself be inferior the whole thing will necessarily be unsatisfactory and in considerable measure second rate.

To put perfect projection on the screen, and maintain it perfectly during even one entire reel, requires ability of no mean order, as well as ceaseless vigilance, and some considerable degree of artistic sense. Not only must the projection machine be kept in perfect condition, in order that there may be no unnecessary movement in the picture, no breaking of the film, or other faults due to a worn or badly adjusted mechanism, but also the light must be pure white, brilliant, and distributed over the aperture with perfect evenness, so there will be no shadow on the screen, other than that of the photography itself, and no discoloration of the light, except that caused by some fault in the film itself.

It requires close study and considerable experience on the part of the operator to be able to determine accurately and at a glance whether a faint shadow or discoloration of the light is due to fault in the light itself or to fault in the film. The operator who proposes to deliver perfect projection must observe and compare closely. He must study projection from all points of view, and above all things must never arrive at the point where he imagines there is nothing more for him to learn. When an operator arrives at that point he will cease to advance in his profession. The high-class operator who produces high-class results on the screen can seldom tell you, except in a very general kind of way, what a film portrays, even after he has run it several times. His whole attention will be taken up in constantly watching for faults in the light, gauging the speed of the projector to suit the action in each scene of the film, and attending to other things in connection with his projection.

And now at this point let me say a few words to managers. In the olden days, so the Good Book says, Pharaoh ordered his Hebrew slaves to make bricks when there was no straw. The Hebrews could not do this, because, the way bricks were made in that ancient day, straw was a necessary part of the proceedings. There are, in this and other countries, many hundreds or even thousands of motion picture theatre managers who are emulating the example of Pharaoh. They are ordering their operators to produce high-class results on the screen but failing to supply them with the necessary things with which to do it—asking them to "make bricks without straw."

The manager who expects his operator to go up into a little 6 by 7 unventilated sweatbox, containing an old style, worn out (or not worn out for that matter—old style is enough) projection machine, and produce high-class results on the screen, is expecting more than he is going to get. It is not in the nature of things and cannot be done. Yet many managers not only do this, but add insult to injury by refusing to purchase necessary repair parts, by doling out carbons one or two at a time, and, in general, making it utterly impossible for their operators to do their work in creditable fashion.

There is another type of manager who will, in the beginning, provide a fairly good operating room and up-to-date equipment, but having done this much considers his duty as wholly finished. These projectors, to his way of thinking, ought to run twelve hours a day for the next six years without even so much as a new intermittent sprocket. He is generous in his advertising, spares no expense in film service, and is, in fact, *liberal in everything except the matter of operating room expense.* Of course, it follows that, under these conditions, his operator is not going to and, in fact, *cannot* produce high-class results on the screen.

These managers, too, frequently go even further than this in their foolishness, and, instead of employing the best operator obtainable, paying him at least a fair salary, get the very cheapest man they can find. Any one who can twist a crank, splice a film and get some sort of a picture on the screen is, in their opinion, an operator, provided he is cheap enough.

The wise manager, the manager who succeeds in any large way, is the one who employs the best operator he can get, provides him with decent working quarters, up-to-date projection machinery, and says: "Now see here, Mr. Operator, within reason you may purchase anything you want in the way of supplies. If I

catch you wasting you will be promptly fired. I only look to you for one thing, and that is results on the screen, but it is results I want, not excuses."

The manager who takes this position is entitled to results on his screen, and he is of the type of man who is going to get them, too.

But to get back to our subject. When the operator is in doubt as to whether some faint shadow or discoloration on the screen is due to the light, or to some fault in the film itself, the matter may be determined by shifting the lamp a trifle. If the shadow or discoloration remains unchanged as the lamp moves, it is due to some inherent defect in the film.

Discoloration or shadows due to light fault are detected by observing white or light colored objects in the picture. A white dress, for instance, must be pure white all over. If a woman is in the foreground and the bottom of her white skirt is in any degree yellow, the rest being pure white, it means that your light is in need of instant adjustment. Very likely the arc is too long. If the discoloration appears at some other point in the picture, it means the same thing, viz., the light requires adjustment, assuming, of course, your lenses are properly matched, so that you can get a clear, white screen. It is not the purpose of this work to tell the operator each separate adjustment to make to overcome or correct every separate fault. This he must learn for himself, by experience. He is presumed to have brains. If he has not a goodly quota of that highly desirable article he has no right place in the operating room. If he has brains, and uses them, he will quickly learn how to adjust the light to correct the various faults.

When the operator is allowed to use sufficient current; is provided with good carbons and the right lenses, there is ordinarily no excuse for any shadow or discoloration of the light.

It may be stated as a matter of fact that with modern films of the best makes it is quite possible to project a motion picture which will be to all intents and purposes absolutely free from movement and absolutely evenly and brilliantly illuminated. This, however, can only be done by a high-class operator who has at his command ample current, high grade carbons, and a carefully selected, up-to-date projection machine.

This, however, must be qualified by the statement that there are only a few makes of films which are to all intents and purposes so mechanically perfect in their perforations

that even a perfect projector will put them on the screen without some movement. In fact, there are none so perfect that there is no movement at all, though the European Pathe and a few American producers are now very close to the ideal in this respect.

Speed of Projector.—The speed at which the film is run is a matter deserving of the closest study and attention on the part of the operator. There are those who insist that some overspeeding of the projection machine lends "snap" to the picture on the screen. This opinion is held by no less person than Mr. S. L. Rothapfel, manager of the Rialto Theatre, New York City. Also Mr. D. W. Griffith, who produced that marvelous production "The Birth of a Nation," holds that it is desirable to overspeed the film. With this view, however, I am unable to agree. I take the position that the actors who enact scenes in films are presumed to know their business, and to enact the scenes in the best possible way. If this be true, then overspeeding of the projector compels the shadow-actor to enact a scene quite differently from the way it was done in real life. Hence if the speeded shadow scene is right, the real scene was wrongly enacted, and vice versa. I have never yet been able to see a horse, for instance, moving across a screen at a speed at which no horse could possibly move in real life, and be satisfied, and I think no one else is really satisfied with that sort of thing. I am a firm believer in the fact that *an exceedingly important part of the operator's work is to carefully gauge the speed of his projector, so that the figures in the various scenes will move in an absolutely lifelike manner,* and this, when you come to think of it, means a great deal. It means that the operator must know exactly what "lifelike manner" is, which involves a close study of many things.

Of course if cameramen always ran their cameras at exactly 60 feet per minute, all that would be necessary in order to reproduce a scene on the screen precisely the way it was acted would be to run the projector at 60 per minute. As a matter of fact, however, cameramen, while they are *presumed* to run at exactly 60 a minute, don't do anything of the sort. Suppose one cameraman misjudges his speed and runs at 58, or two feet under normal, whereas the cameraman taking the next scene misjudges his speed in the other direction, and runs at 62. Now if the projection machine pounds along at 60 a minute, one scene will be run too slow and the other too fast, or if the whole thing be run at either 58 or 62, one scene will be correct and the other very far from right.

The operator who thinks that the finer details of projection are not of sufficient importance to justify him in giving them attention is not and never will, in my opinion, be a high-class man.

It is quite true it usually is a difficult and discouraging task for the operator to secure recognition for high-class work. In fact, many managers won't let him deliver high-class work, but, nevertheless, the man who persistently and consistently bends his energy to improving his projection in every possible way is, I think, bound to win out sooner or later. High class work cannot but be noticed. It may take considerable time; it may be discouraging, but success will come, and with it, at least in some degree, financial reward.

Almost the same thing may be said of the manager. The manager who employs a high-class operator, pays him an adequate salary, provides him with good working conditions, tools and supplies, and insists on high-class projection, may not immediately see the benefit. Nevertheless the public in due course of time will recognize the fact that in a certain theater they are sure to see a good picture, and, other things being equal, they are going to patronize that theater.

Overspeeding the Machine.—Overspeeding the machine is a reprehensible thing from any and every point of view. It is an all too common fault, practiced by managers of theaters who have no respect for the property intrusted to their care by the film exchange and no adequate conception of the business of exhibiting motion pictures or their duty toward their patrons. There is a certain type of manager who seems to have an ingrowing idea that the public collectively is a fool; that it would rather see six reels put on the screen as a ridiculous travesty on projection—as an absurd jumping-jack performane, than see five reels put on the screen right. They insist on shooting a reel of film through in less time than is required for its proper projection. There are managers who will talk to you learnedly about a reel requiring "fifteen minutes," or "eighteen minutes," according to their individual ideas. They have no adequate knowledge of projection themselves, and don't understand the fact that, whereas one reel of film may require only fifteen minutes (nine reels out of ten will require more time than that), another may require as much as twenty minutes; both fifteen and twenty being extremes. Many "managers" insist on putting on a six-reel program in the time that ought to be consumed by five reels. Over on the east side of New York City I have actually seen one thousand feet of film projected in considerably less than ten minutes.

Overspeeding the machine is an outrage on the public; an outrage on the producer; an outrage on the film exchange; an outrage on the projection machine manufacturer, and an outrage on the operator himself. There is no excuse for it—absolutely none at all. If the house is full and a crowd waiting to gain entrance it would be far better to cut out one reel than to injure the whole performance.

The operator is very seldom to blame for this particular thing. Nine times out of ten it is the manager himself who commits what amount to a crime against the business, when he orders overspeeding of the films. A film might be run at the rate of 70 feet (70 turns of the projector crank) per minute without undue strain to the film, but if long continued it will inevitably injure the projection mechanism. If one will but pause and consider: There are sixteen pictures to each foot of film. Each picture must stop dead still over the aperture, and then be displaced by the next one after exposure, all in one-sixteenth of a second when running at normal speed. This means that the strip of film between the upper and lower loops must start and stop sixteen times each second. If the crank speed be increased to 70 per minute it means that this stoppage and starting must take place at the rate of nineteen per second, instead of sixteen.

At 80 turns of the crank per minute it means that twenty-two pictures (almost) will be exposed each second. Not only must the strip of film between the two loops be started, against the considerable pressure of the tension springs, at this terrific speed, but also the intermittent shaft, star and sprocket must also be started and stopped at the same rate. It requires but slight knowledge of mechanics to understand the strain thus placed on the sprocket holes of the light, fragile film, as well as on the intermittent movement of the projector. Overspeeding also makes necessary a tighter tension, which still further aggravates the damage. The camera which took the scene is supposed to run at 60 a minute. Films and projection machines are intended to withstand the strain of 60 a minute and will do so. When, however, this speed is exceeded to any considerable degree the strain multiplies rapidly, and the consequent wear and tear is several times what it is at normal.

Effect of Loss of Definition.—One factor enters very largely into projection which is very little understood by the average manager and operator. This matter has been called to my attention by Mr. Nicholas Power of the

Nicholas Power Company, and while I have never thought of it in that connection before I believe Mr. Power is absolutely correct.

Patrons frequently complain that "pictures hurt their eyes," even when there is no trace of flicker. Managers and operators have been puzzled to account for this. Mr. Power's explanation of the matter is as follows:

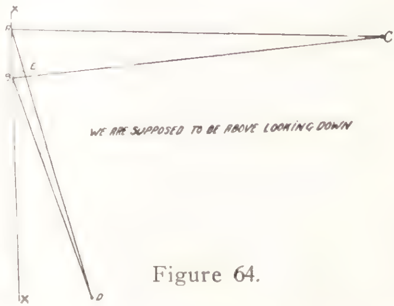


Figure 64.

Take a carbon copy of a letter or long article, and attempt to read it. You will find that before you have read very far your eyes begin to hurt and even to water. The reason for this is found in the blurry appearance of the copy, and the more blurry the carbon the greater will be the strain on the eye.

The same holds true with pictures. If the definition on the screen be not absolutely sharp, the effect on the eye is a strain, and not only is this effect present where there is lack of definition through fault of the camera or the projection lens, but it is also present where there is a travel ghost.

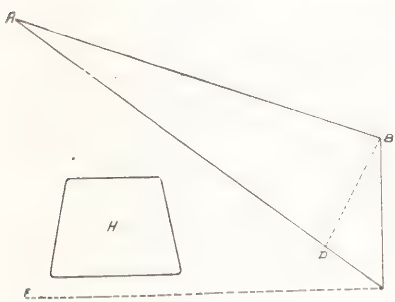


Figure 65.

This, it seems to me, is an important point, and, moreover, it is a new point. I believe this is the first time it has received consideration. I would advise managers to look into this matter and to use every endeavor to have the definition on their screen as sharp as it can possibly be made and travel ghost entirely eliminated. Of course, we all know that from any point of view the loss of definition and travel ghost is bad, but viewed in this light it becomes doubly obnoxious.

Side View.—Many times the question has been asked: "Why do the screen figures look abnormally tall and thin when viewed from a heavy angle?" This is clearly explained in Fig. 64, in which two people, C and D, view a figure having a normal width of A-B on screen X = X. C gets the full benefit of this width, as per lines A-B, but D only gets the effect of width as per dotted line B-E, for reasons which are self-evident.

Keystone Effect.—Where the machine is set above the level of the screen the bottom of the picture will be wider than its top, thus producing what is known as "keystone effect," as shown at H, Fig. 65. This effect is due to the fact that the light ray spreads out as it travels, and to the further fact that it must travel farther to reach the bottom of the screen than it must travel to reach the top when the angle of projection is downward.

This is illustrated in Fig. 65, in which A is the lens of the projector, B-S the screen and F-S the horizontal distance of projection, H, being a detail to show shape of picture under these conditions. If the top of light rays A, B, S, are all to travel the same distance to reach the screen, then the screen would necessarily be located at B-D, and the picture would have its normal shape, but since the bottom of the screen is at S, it follows that to reach the top of the screen the light rays must only travel from A to B, whereas in order to reach the bottom it must travel from A to S, or the distance D-S in excess of distance A-B. Now assuming A-B to be 60 feet and the top of the picture to be 15 feet wide, and the distance D-S to be 3 feet, we would have a light ray which spreads $15 \div 60 = .25$ of a foot, or $12 \div 4 = 3$ inches with each foot of throw. Hence it follows that distance D-S being 3 feet, the width of the bottom of the picture would be $3 \times 3 = 9$ inches greater than the width of the top of the picture. The same thing as applied to a 40, 30 and 15 degree angle on an 80-foot throw is fully illustrated in Fig. 66.

The same condition prevails when the machine is set to one side of the center of the screen, except that in this instance the keystone effect will be sidewise—that is to say, one side of the picture will be higher than the other side. There is, however, this difference: The up and down keystone effect is, for some reason which I have never been able to understand, never accompanied by as great a tendency to out-of-focus effect as is the side keystone. The instant the machine is set to any considerable distance to one side of the center of the screen difficulty is encountered in getting a picture

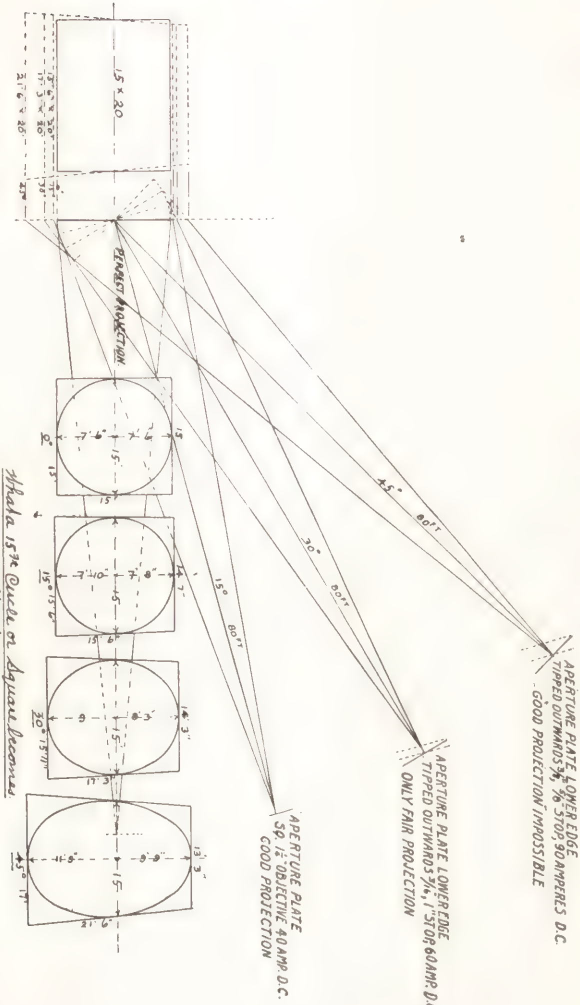

15 x 20
PERFECT PROJECTION
What a 15 ft Circle or Square becomes.
GOOD PROJECTION
ONLY FAIR PROJECTION
GOOD PROJECTION IMPOSSIBLE

Figure 66.

which is sharp all over, and if the machine be set much to one side it will be found practically impossible to get even a reasonably good picture. It is no unusual thing, however, to have a machine giving a fairly sharp definition all over the picture with a drop in projection of fully 40 feet in 100. Of course a portion of this difference in effect is accounted for by the fact that the picture is wider than it is high, but this does not seem to explain the whole thing, as a fairly sharp picture may be had with very steep downward pitch.

The keystone effect, so far as the outline of the picture is concerned, may be corrected by filling in the projector aperture with hard solder, and then carefully filing it out until the picture assumes its normal shape on the screen.

The best and in fact the only practical way to do this is to fill in with solder and file the aperture to shape when the light is on, first, however, having removed one of the condensing lenses so that the spot will be very large, since otherwise it will be too hot to work in. By this method you can watch the exact effect of every stroke of the file upon the outline at the screen. Be very careful that you do not get a little too much off, because if you do you will have to do the whole job over again. If the machine sets above the screen the filing will have to be done on the sides of the aperture, the lower part of the aperture being made widest. If the machine sets to one side of the screen then the top and bottom will have to be filled in. Before beginning, hang a narrow strip of black tape, weighted at its lower end, with its upper end just where the lower end of the upper corner bend comes. This will supply guides so that you will get the side lines perfectly straight and perpendicular. Bevel the sides of the aperture opening slightly on the screen side.

As before stated the outline of the picture can be corrected in this way, but the distortion of the picture will remain. That cannot possibly be corrected, except by setting the machine lens central up, down and sidewise, with the center of the screen.

The out-of-focus effect which accompanies keystone effect where the machine is set to one side of the center of the screen may, if it be not too great, be corrected by loosening the aperture plate and placing a thin strip of metal under one side, the idea being to slightly raise one side of the aperture plate, provided it be a type of machine which will allow of its gate being squared with the aperture in its new position. Up and down keystone effect can also be corrected by blocking the upper end of the aperture plate out somewhat; but

this cannot be carried very far, or trouble with the tension shoes will be encountered.

Amperage

(Also see Limit of Amperage, Page 292.)

The number of amperes to be used for the projection of a given size picture depends, to a large extent, on the screen surface used and the kind and amount of auditorium lighting; the percentage of light cut by modern projectors varying but little from 50 per cent.

There are still those who commit the error of assuming that the distance of projection (throw) has much to do with the necessary volume of light; also there are still those who attempt to apply the well known law that "light intensity diminishes with the square of the distance."

Let me again correct these impressions. Provided the lens system of the projector be properly matched, it makes, within reasonable limits, but very little if any practical difference what the distance of projection is. With the arc at a given distance from the condenser a certain amount of light is distributed over the area of the spot, and a certain percentage of this light intensity passes through the aperture of the projector and, of course, the film. If the lens system is properly matched, practically, all light passing through the film will enter the objective lens; also practically all light entering the lens will leave it (I am laying aside, for the time being, the absorption of light in passing through glass); and, once having left the lens, a moment's thought will convince even the most skeptical that if a ray of light can travel ninety-three millions of miles from the sun to the earth, a difference in distance as between 50 and 100, 150 or even 250 feet is not going to make any practical difference, provided the atmosphere be even reasonably free from dust and smoke, which would cause more or less diffusion.

In Fig. 67 we see an illustration of the law: "Light intensity decreases inversely with the square of the distance." In this illustration A, B and C represent different positions of a screen. Light rays emanating from a central source travel in straight lines in all directions. It requires but a glance to see that, this being the fact, these light rays will spread fanwise as they travel, and that in position C the screen would receive only a comparatively small percentage of the light it would receive if it were in position A. In fact, screen B would have to be as large as is indicated by the

dotted lines in order to receive the same total illumination received by screen A, which would, of course, greatly reduce the brilliancy per unit of area, and screen C would need to be still larger in order to catch the same number of rays screen A receives. This is a very plain illustration of the

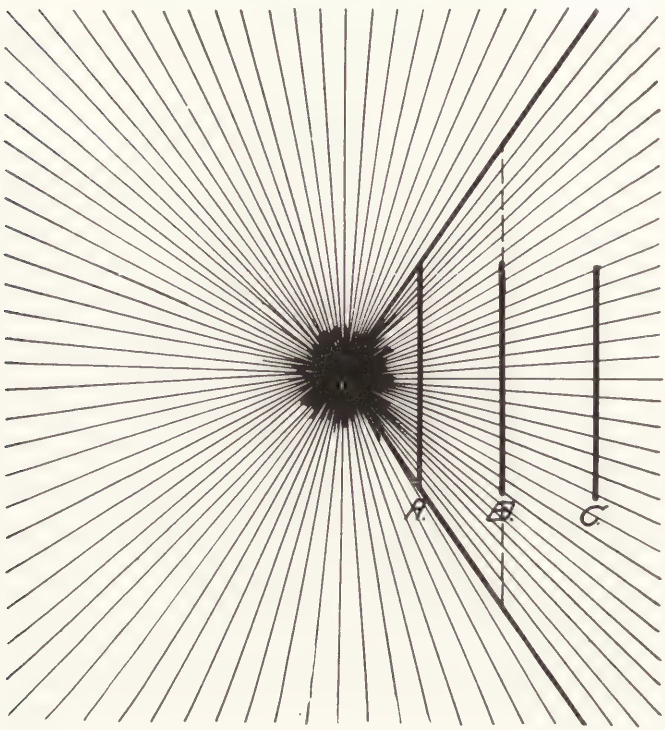


Figure 67.

law in question, but this law does NOT apply to projection, except in a very modified fashion.

In a projection machine we have an arc lamp with the crater forced into a position where it will face the condensing lens as squarely as possible. By reason of this condition a certain given and very high percentage of the

light emanating from the crater on the carbon strikes the rear surface of the condensing lens, and is by that lens projected to the spot, where again a certain definite percentage passes through the aperture of the machine. Now the light which passes through the aperture and film passes on and into the objective lens, where it is given a certain definite direction. The rays do *not* spread out in *every* direction, as per Fig. 67, but *only on the lines determined by the curvature of the lens,* therefore the light intensity of the screen is proportional to the total candle power of the light ray at the front end of the objective lens as compared to the area of the screen.

Loss of Light in Lenses.—At this point it is, I think, proper briefly to consider the loss of light in the lens system. It is a well known and established fact that, in passing through glass, light loses a certain proportion of its intensity. This loss has been variously estimated by different authors, but it appears to me the conclusion arrived at by Mr. J. Frank Martin, of Pittsburgh, Pa., in a paper entitled, "The Illumination of Motion Picture Projectors," read before the Pittsburgh section of the Illuminating Engineering Society, April 18, 1913, is the first and only authoritative statement concerning the loss of light in the lens system of a projection machine.

I would not by any manner of means wish to be understood as indorsing the conclusion arrived at by Friend Martin. In fact, it seems to me those conclusions lead to an impossible screen effect, but, nevertheless, as I before said, they are the only authoritative statements I have ever seen on the subject. Mr. Martin says, in part:

"Many different combinations of lenses have been experimentally developed, but no radical changes have been made from the earliest form used in the magic lantern. The lens system and the losses therein are illustrated in Fig. 68. The projector lens system has been built up with a point source of light as a basis; hence the low efficiency of 10 per cent. is not surprising, and there is apparently great opportunity for improvement."

The diagram will be of great interest to operators; also it will have for him some surprises. However, I do not think the right impression is conveyed when Mr. Martin says there is an efficiency of 10 per cent. *at the screen.* This does not seem to me to be a fair statement of fact. As I understand it, Mr. Martin assumes an efficiency of 10,000 c.p. at

the arc, meaning by this that the surface of the crater itself has a total light efficiency equal to 10,000 c.p., but after the rays have spread and a portion of them have been lost in the interior walls of the lamphouse, there remains only an efficiency of 200 c.p. at the surface of the front condenser.

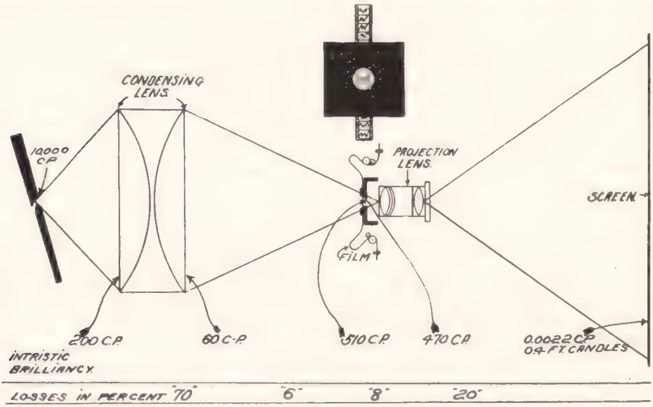


Figure 68.

Now what I understand this to mean is, in effect, that if the area of the crater could be magnified to the size of the condenser and, without considering the light loss in the interior lamphouse walls, it still, as a whole, gave off 10,000 c.p., the light giving power per unit of area would be reduced to 200 c.p., or, putting it in another way, the diminution of light intensity per unit area of measurement amounts, by reason of the spreading of the light rays, to a difference between 10,000 and 200.

And now comes something that will be mighty interesting to the average operator, viz., the loss of 70 per cent. in the condenser itself. This loss Mr. Martin holds is, to a considerable extent, due to the use of low grade glass in cheap condensing lenses. The lenses used in the test were a pair of 6½ and 7½ plano-convex, of the ordinary variety. The test was made with a Sharp-Miller photometer, by placing a standard test plate at the point where it was desired to measure the brilliancy. This test plate is a smooth, white surface which reflects a definite proportion of the light from its surface. By placing such a test plate flush with the sur-

face of the condenser, next the arc, and measuring the light reflected therefrom, it was found that 200 c.p. was the brilliancy of each square inch of the condenser surface. The arc had been previously adjusted and placed in a position that gave a clear, round spot at the aperture of the machine. When this test plate was moved to the surface of the outer condenser, and the indication taken in the same manner, 60 c.p. per square inch was the light intensity recorded, which indicates the astonishing loss of 70 per cent. in the condenser itself. This does not, at first blush, appear to be reasonable, nor do I believe it represents exactly the fact, because a slight alteration in the length of the arc may (I don't say it would, but it might) affect a considerable difference in the *quality* of the light, which might operate to diminish its brilliancy. Nevertheless, whether the figures are accurate or not they certainly do show that the condenser absorbs an enormous percentage of the light. Nor are we altogether surprised that this is the fact when we remember that the thin filament of glass contained in an incandescent light globe causes a loss of 3 per cent. You would hardly think this latter were possible, but illuminating engineers tell us it is the fact.

This tremendous condenser loss certainly points to the enormous importance of using high class condensing lenses—the best that can be had, and even then the loss would be very great. The inefficiency of the condensing lens was very thoroughly proved to the writer when he witnessed the demonstration of a parabolic reflector designed to concentrate the light without the use of condensing lenses. He was literally amazed to witness the projection of a really brilliant, beautiful sixteen-foot picture with only slightly in excess of 12 amperes of current, using an ordinary muslin screen. This reflector, or light concentrator, has never as yet been got into a form where it is practical for general motion picture work, but it did show the tremendous gain which would be made possible if the condenser could be eliminated. Moreover, the light had a white, mellow, pleasing quality the writer has never seen in an illumination which has passed through condensing lenses.

But to return to our subject. Referring to Fig. 68, we find that the test plate, when placed at the aperture of the machine, showed a brilliancy of 510 c.p. per square inch, but that immediately after the light had passed through the film only 470 c.p. was shown, which indicates a loss of 8 per cent. in the film itself. The film used was a clear piece from which

the photographic emulsion had been removed. Therefore it appears that the celluloid of the film itself absorbs 8 per cent of the light.

And now comes the point which makes this whole thing appear to me as rather impossible, except viewed from the standpoint of proportions of loss. It seems to me that, if the aperture had an area of one square inch, and the light brilliancy passing through it were only 470 c.p. per square inch, then the screen itself could only have a brilliancy per square inch equal to 470 divided by the total square inch area of the screen, which would give us an actual screen brilliancy of only a very, very small fraction of one candle power. As a matter of fact even that result would be too high, because the area of the aperture is only about three-quarters of one square inch, therefore the real screen brilliancy would be three-quarters of 470, divided by the square inch screen area, and even that would be reduced by the 8 per cent. loss in the *objective lens.*

I have given this matter space because of the fact that it points an entrance to a road which needs thorough exploring, and needs it badly, too. The projection lens itself, being of very high grade glass, only entails a loss of 5 to 12 per cent., averaging, Mr. Martin says, 8 per cent. The thin bulb of an incandescent lamp, made of ordinary glass, causes a light loss of 3 per cent. Now the total glass in the two combinations of the ordinary projection lens will, I think, measure about five-eighths of an inch in thickness. If it is true that less than one-thirty-second of an inch of ordinary glass causes a light loss of 3 per cent., and approximately five-eighths of an inch of very high grade glass causes a loss of only about 8 per cent., it would seem to be readily apparent that *there would be an enormous gain in using very high grade optical glass for condensing lenses.*

It is but a step from this result to the inevitable conclusion that there is a huge duty devolving upon machine manufacturers to evolve some method of absolutely stopping the breaking of condenser lenses, to the end that really high-class, expensive ones may be used. Already the Elbert and Preddy condenser holders have paved the way. Altogether too little attention has been paid to this extremely important matter in the past.

To get back to our main subject. Broadly speaking the number of amperes necessary to produce a given curtain illumination will depend upon the number of square feet contained in the screen, the character of surface of the screen and the percentage

of light cut by the revolving shutter. As set forth, the modern projection machine will, under the best conditions, cut approximately 50 per cent. of the light, and under adverse conditions may cut somewhat more than this, though the variation either way from 50 per cent. will be but little. The area of the screen, and the character of its surface, however, are largely governing factors. Suppose we are projecting a picture 8 by 10 feet at 60 feet. In a space 8 by 10 feet are 80 square feet of surface. Now, understanding that practically all light rays leaving the objective lens reach the screen, while light rays are really numberless, let us suppose, for purpose of illustration, that we have exactly 160 rays of light leaving the projection lens. This would, of course, mean that each square foot of screen would be illuminated by just two rays of light.

Now suppose we change our lens to one projecting a picture 12 by 16 feet, which would have 192 square feet of surface. The total light remains the same, but the surface has been *more than doubled*. It therefore follows that the light, being spread over more than twice the area, has been weakened, so far as screen illumination be concerned, by more than one-half. Where we formerly had an illumination equal to that produced by two rays for every square foot of screen surface, we now have an illumination less than that equal to one ray to the square foot. We still have exactly the same total amount of light, but have, in limited degree, invoked the law of inverse ratio already spoken of.

We thus see that *illumination decreases as the area over which it is spread is increased*. It therefore follows that if the size of the picture (area) be increased, it will be necessary, in order to maintain the same brilliancy, that the power of the light, or, in other words the amperage, be also increased to a value which will supply to each square foot of screen surface the same intensity of illumination it received in the smaller picture.

In the second edition of the Handbook I gave an amperage table which was presumed to be satisfactory for use with any good, non-reflective screen, such as a plaster wall, calcimine surface, white muslin, etc. I see no reason for making any changes in this table, except to say that the modern tendency is for more brilliant illumination, and this would increase the figures given, I believe, by very nearly 25 per cent. In other words, high-class theatres of today would probably use nearer 50 amperes than 38 on a 15 foot picture. I shall, however, give the tables unchanged, but with the foregoing modification. Those who wish to follow up-to-date practice are recommended to increase the amperage given by 25 per cent. In the "Amperes A. C." column of the table I have made 60 amperes the limit—

this by reason of the fact that operating room transformers (compensarcs, inductors, economizers, etc.) almost without exception have a 60 ampere maximum capacity. As a matter of fact, however, not less than 90 amperes A. C. should be used on a 20 foot picture and an 18 foot picture should have not less than 75 or 80. Where A. C. is used on large pictures I would recommend two economizers wired in multiple. The figures given in the table are based on the presumption that the screen surface is in good condition.

TABLE 3.

Picture.	Area Sq. Ft.	Amperes D. C.	Amperes A. C.
6.75 x 9	61	20	35
7.5 x 10	75	20	35
8.25 x 11	91	20	35
9 x 12	108	22	35
9.75 x 13	127	25	38
10.5 x 14	147	29	44
11.25 x 15	169	33	50
12 x 16	192	38	58
12.75 x 17	216	43	60
13.5 x 18	243	45	60
14.25 x 19	268	45	60
15 x 20	300	45	60

Another governing factor in the matter of amperage is the type of screen surface used. There are on the market a number of semi-reflective so-called metallic surface screens, and one make of glass surface screen. The principal value of these screens lies in the fact that a greater curtain brilliancy may be obtained with a very considerable less current consumption than is necessary with the non-reflective screen surfaces. This matter will, however, be dealt with more extensively under the heading "The Screen," Page 166.

We have learned that screen brilliancy will not depend upon the total amount of light projected to the surface of the screen, but upon the total amount of light projected to *each square foot* of screen surface. This brings us to the inevitable conclusion that

A certain given amperage per square foot of screen surface will give a certain definite brilliancy of illumination to the screen, other things being equal.

There are, of course, many equations entering in less degree into this matter. We are only speaking in generalities. For instance, curtain brilliancy will to a certain extent depend upon the set of the carbons and the angle of the lamp, but

at this stage of affairs even the tyro operator is supposed to have a fairly good knowledge of carbon setting and lamp angle, since there is but one correct setting and one correct angle, modified only to some extent by the pitch of the projection machine itself.

The amperage will also depend, to some slight extent, on the clearness of the atmosphere, to a considerable extent and amount on the auditorium lighting, upon the density of the film, upon the grade of lenses used, and the matching of the optical system. All these are more or less potent factors, and no set rule can be given, nor can any table be given which will meet all conditions.

The following very interesting table shows the increased percentage of light made necessary by increasing the size of the picture, for instance: If you have a six foot picture and desire to increase it to seven feet: The area of your six foot picture is 26.4 and the area of your seven foot picture is 35.9 square feet, an increased area of 9.5 square feet, which will require 36 per cent more light. In other words, to illuminate a seven foot picture to the same brilliancy as a six foot picture would require 36 per cent more light. The percentage, however, decreases as the size of the picture increases; that is to say, there is a less percentage between the ten and thirteen foot than between the eight and twelve foot picture. This table ought to form a very interesting study for operators. It is based on the fifteen-sixteenths inch aperture.

TABLE 4.

Width in feet.	Height in feet.	Area sq. feet.	Area increase in sq. feet.	Percentage of increase area.
6	4.40	26.4	....	..
7	5.13	35.9	9.5	36
8	5.87	46.9	11.0	31
9	6.60	59.4	12.5	26
10	7.33	73.3	13.9	23
11	8.07	88.7	15.4	21
12	8.80	105.6	16.9	19
13	9.53	123.9	18.3	18
14	10.27	143.7	19.8	16
15	11.00	165.0	21.2	15
16	11.73	187.7	22.7	14
17	12.47	212.0	24.2	13
18	13.20	237.6	25.6	12
19	13.93	264.7	27.1	11
20	14.67	293.3	28.6	11

The Screen

THE particular and only function performed by the screen of a moving picture theatre is to reflect "picture light." We see the picture precisely for the same reason that we see any other object. As light rays are reflected from various objects to the eye, so, in projection, light rays reflect from the screen to the eye. The picture appears plainer, sharper and better if "picture light" *alone* is reflected and if the "picture light" is abundant.

There is very great difference in screen surfaces and in results from the various surfaces, yet IT IS UTTERLY IMPOSSIBLE TO JUDGE OF THE COMPARATIVE VALUE OF RESULTS OBTAINED FROM VARIOUS SCREEN SURFACES UNLESS THEY BE PLACED SIDE BY SIDE, SO THAT THE SAME PICTURE MAY BE PROJECTED BY THE SAME LIGHT, ONE HALF OF IT ON ONE SCREEN AND THE OTHER HALF ON THE OTHER. It is impossible to properly judge of screen surface values by looking at screens in different theatres, by reason of the fact that there are seldom or never two screens in neighboring houses where all factors are equal and the working conditions are precisely alike. The brilliancy of the projection light may be different, due to (a) difference in amperage, (b) in carbon set, (c) in carbons, (d) quality of current, (e) machine shutter. Also general results may be altered by difference in the decoration of the theater auditorium; in the border surrounding the screen; in the length and width of the theatre; in the distance of the screen from the auditorium proper; in the size of the screen; in the angle of the throw, or in other things. In fact these many and varying equations make it absolutely impossible to realize the true value of a screen surface by the plan of going from one theatre to another, depending on the eye alone to judge relative values. For example, changing from a small screen to a large screen will cause the "picture light" to appear, by comparison, less brilliant, assuming other conditions to be equal in both cases. A change from a screen of 100 square feet area to one of 200 square feet area will cause the large screen, if the two surfaces be alike, to appear 50 per cent. less brilliant than the smaller.

It is even impossible accurately to judge of different screen surfaces by projecting a picture on one screen and then substituting the other therefor, projecting upon it the same picture. This by reason of the fact that the light may not be the same. Something may have happened to drop the supply voltage slightly, which would effect the amperage at

the arc, and hence the light. The operator may not have his carbons adjusted precisely the same in both instances, which would or might cause a change in the screen brilliancy. In view of these facts the only right way is the one I have suggested. That kind of test is absolutely fair to everybody and it is not a difficult one to make either.

I would most emphatically warn the operator and manager of the danger of judging hastily as between screen surfaces. I would also caution managers and operators against the too ready acceptance of the statements of salesmen as gospel truth. Salesmen are employed to *sell goods,* and some of them, I am sorry to say, don't always confine themselves to statements which the facts will bear out.

As a matter of fact I now have an instance before me in which an exhibitor paid $75.50 for a screen. It was a good screen, too, the surface being guaranteed for five years. But not very long after it was installed along came a nice, smooth-talking artist, in the shape of a salesman for another brand of screen. Now this other brand of screen was not one iota better, even if it was really as good, as the screen the man already had, yet, as absurd as it seems, the salesman actually talked the manager into paying $225 for a new screen. The part of this which makes the transaction particularly dishonest is the fact that the new screen could unquestionably have been sold at a good profit for the same price he paid for his other one, viz: $75.50. Verily there seems to be a new sucker born every minute, and *some of these are found in moving picture theatre managerial capacities.*

The time will, I presume, come when the screen business will settle down to a solid basis, and some type of screen surface will be found to be best and become standard. At the present time, however, I cannot do more than point out to theatre managers and to operators *the necessity for demanding that screen salesmen give them at least reasonable proof of the correctness of their statements, and that proof is best given by actual demonstration as before outlined.* It is not at all impossible for a screen salesman to carry with him a sample surface large enough to cover half of any ordinary theatre screen. *Make him hang the sample up over half of your screen and show you, always remembering that a new, clean screen surface is, of course, somewhat more brilliant than one you have been using for a year or two.* Don't attempt to judge from a small sample, however. Make him cover one-half of your screen with his sample.

As a matter of fact, when it comes right down to absolute accuracy, it would be necessary to build a screen to meet the requirements of each individual house, but this is, of course, impractical, nor would the added benefit justify the necessary amount of labor and extra expense involved.

Light.—As stated, the only function of the screen is to reflect light. Therefore, in order to understand results emanating from a certain screen surface we must first understand a few of the many laws governing light action. Light travels at the almost incomprehensible speed of 192,000 miles a second. This speed is such that we have no way of controlling it; therefore its speed cannot be altered. This is an item that is of no interest to the operator, except as a matter of general information. There are two kinds of reflection, viz:

Regular Reflection and Diffuse Reflection.—Regular reflection occurs when light strikes a smooth, polished surface and is not broken up and scattered, as, for instance, the reflection from a looking glass. Example: We see ourselves in a mirror because light reflects from our face to the glass, and comes from the glass into our eyes without being scattered or diffused.

Diffuse reflection occurs when light comes to the eye from a body which has a roughened, unpolished surface, which by reason of its roughness, scatters or diffuses the light rays.

Reason for the Haze.—Surfaces which have, to a certain extent, both the elements of polish and roughness, reflect both regular and diffuse reflection, and thus produces a haze, by reason of the fact that the regular reflection is superimposed over or upon the diffused reflection. This is a peculiarity of the polished metallic screen surface, and explains the reason for the failure of many home-made metallic surface screens.

Light Travels in Straight Lines.—Light rays travel from their source to a surface in perfectly straight lines, and when the light is reflected from a surface to the eye it again travels in perfectly straight lines, providing, of course, the air or space between be a perfectly transparent medium, of uniform density. Light may travel from one surface to another several times, and the direction of its rays change in each instance, but the *traveling* is, nevertheless, always, subject to change of density in the medium, in straight lines.

When light strikes a roughened surface, the minute roughened elements, which we may term "peaks and depressions,"

will cause it to scatter and reflect in all directions. The direction of the reflected rays depend upon the angle of these minute peaks or depressions, and upon their location with reference to the source of light. "Picture light" projected upon a screen is reflected from the screen into the eye from the various peaks and depressions upon the screen surface, and is scattered in a narrow or wide angle in exact proportion to their size.

Peaks and Depressions. These peaks and depressions are small, and, as a general proposition, invisible to the naked eye. A single ray of light is of exceedingly small dimensions. Scientists tell us that a bundle composed of thirty-six light rays has the same area as that of an ordinary human hair. The peaks and depressions which scatter light may be just as minute as is the diameter of a light ray. It is not to be understood that I am referring to a surface so rough that the human eye can see the roughness. A surface may have a rough matte appearance, and yet the minute elements in that surface may be very smooth, and therefore not cause perfect diffusion of the light, whereas a surface which may appear smooth to the eye might be of such character that it would scatter light rays in all directions, and thus create perfect diffusion. In other words light rays and elements of surface that scatter light are both almost of an infinitely small dimension.

Matte Surfaces.—It must be understood that, given the peaks and depressions, as above set forth, there is an added value and a very decided added value if the surface of the screen be also visibly roughened, that is to say, if it be of a matte character. This matte or visible roughness is not an absolute necessity, provided the smooth surface be of the proper character, but it is nevertheless eminently desirable since it adds very materially in the production of a perfect picture. True, the matte surface has little or nothing to do with the actual diffusion of light, but nevertheless it performs another important function, in that it enables the eye to see the picture more clearly and in greater detail when viewed from a side angle.

Interfering Light.—One of the prolific causes of failure to secure clearness, brilliancy and beauty in the picture is what may be termed "interfering light." Interfering light is any light other than "picture light" which strikes the surface of the screen. It may be caused by (a) stray light beams from the operating room, which strike the wall or ceiling and are

reflected to the screen. These rays usually emanate from the condenser; they can be and by all means should be eliminated. (b) Daylight, which is a most prolific cause of poor results at matinee performances. *It is amazing how little attention managers and operators pay to the thorough excluding of daylight from the auditorium at matinee performances.* Any daylight which reaches the screen, no matter how slight in amount, is distinctly detrimental to the picture. That is an absolute fact, which it seems to me any operator or manager ought to realize and understand. (c) House lights improperly arranged, or improperly shaded. This is another point concerning which some managers display an astonishing amount of crass ignorance or carelessness or both. I have actually gone into a theatre of considerable pretension, charging a good admission price, and found the white light from incandescent lamps shining directly on the screen, or found the white light shaded from the screen but glaring directly into the eyes of the audience. I do not care to take up the matter of house lighting here, but under the proper heading these things will be dealt with and such information as is available will be given on the subject of house lighting.

Exhibitors and operators should be continually examining the screen, keeping a sharp lookout for stray light. They can only do this best when the projecting machine is not working—no picture or projection light on the screen. The screen should then look the same all over, with absolutely no shadows.

After having examined the screen, with the entrance doors closed, open them and see whether there is any difference, and whether, when the entrance and exit doors are swung open, shadows appear on the screen. If so, then the necessary steps should be taken to exclude the rays which cause these shadows. A few screens or double doors will very likely remedy the matter, remembering always that at matinee performances the shades on the windows must be absolutely light tight in order to get the best effect. This is best accomplished by tight fitting wood or metal shutters, though two dark-colored shades, with their edges running in grooves not less than one inch deep, will serve. One will do fairly well, but is likely to develop pinholes; two are much better.

Standing beside the screen, looking toward the auditorium, there should be no light visible to the eye at any point. If there is, then that light is reaching the screen and doing injury to the projection.

Indirect lighting has been one of the best aids in eliminating stray light from incandescent lamps, but it is often improperly installed, and in many instances an indirect lighting fixture reflecting light against the ceiling and thence to the screen will cause more interfering light than any other possible installation. This by reason of the general practice of allowing too many and wrongly located fixtures to be illuminated during the show, and too much illumination per fixture. See "Lighting Auditorium."

Tolerably dark wall decorations are a great aid in eliminating stray light; also they are more restful to the eye. Dark colors, such as green, give the picture greater contrast, and absorb interfering light. Daylight, however, is not only the most difficult of all stray light to exclude, but is also the hardest to absorb, and in hundreds of instances its presence robs the picture of beauty and detail. Dark decorations on the walls, however, can easily be carried to excess. There is room for good judgment and common sense here. It won't do to make the theatre gloomy; there is an extreme both ways.

Distribution of Light.—The screen not only reflects light to the eye located at one point, but the degree of roughness in its surface causes the distribution of light in all directions toward and throughout the auditorium of the theatre, so that the picture becomes visible from every point therein, and if the screen surface be such that distribution is even, then the picture will be as bright from one point as it will from another.

In fact one of the important points of difference which appears when comparing various screen surfaces is the difference in the direction these surfaces reflect the picture light.

We may properly divide screen surfaces into four classes, viz: three classes of direct projection screens and one class of rear projection screens.

First: A White Wall or Sheet.—These surfaces were in general use for many years, and are still used to a large extent, particularly in the smaller towns. The white sheet should be made of a reasonably good grade of bleached muslin, which may be had as wide as 108 inches. It must be stretched perfectly tight and be entirely free from sags and wrinkles. The plaster wall needs no description. It must, of course, be perfectly flat and finished with a white, hard coat.

When light strikes the white wall or sheet the peaks and depressions are so large, as compared with the wave length of light, that the light is reflected in very wide angles, and on

this account a great proportion of the light is lost to the auditorium proper. The proof of this is that a white wall will appear brighter when one is up close to it or to the side of it than will any other screen, whereas it will appear darker in front and from the various points in the auditorium of the theatre. A metallized screen, or mirror screen placed against such a surface, will show a very great difference in brilliance of illumination. Therefore it is not possible to secure any very high percentage of efficiency with a white wall or cloth screen, as compared with the efficiency secured with semi-reflecting screen surfaces, because much of the light from the wall or sheet is not reflected to the viewing space of the auditorium, but in other directions.

Second: Metallized Screens.—Screen surfaces coated with various secret compounds containing more or less aluminum or other metallic substances are now quite popular. Metallic screens have for their base some kind of cloth, to which is applied a preparation containing a percentage of aluminum or bronze, though as a matter of fact in some of the modern "metal" surfaces but little actual metal is used. Screens also have been made from tinfoil, attached to cloth and coated with celluloid. This formed the surface of the "Day and Night" screen which was exploited for a considerable time.

Bronzes and aluminum paints are difficult and impractical to apply in such manner as to secure perfect light diffusion, and the exhibitor should always buy such screens from reliable manufacturers who make a study of the preparation of such surfaces, and who usually supply stretching devices which allow of the screen being properly installed.

Results from metallized surface screens depend upon the character of the surface. Evidence that the peaks and depressions on many metallic surface screens are smaller than on a white wall or sheet may be had by viewing the surface with a microscope, and when this is the fact, the effect is visible to the eye by viewing the screen from an angle and noticing the difference in the amount of light reflected from the side and the amount reflected straight back. You will usually find that away up to one side the "picture light" becomes weaker, but as you go in front of the screen, at some distance away, it becomes very bright.

For a wide house a special surface should be made which will distribute light at rather a wide angle, while for a narrow house the highest efficiency is produced by a brilliant surface which concentrates the light to a narrow viewing angle.

The reflection of light by the screen is just as difficult and important an optical problem as is the projection of the picture itself, and even as a lens which projects a 9 by 12 picture at a certain distance does not and cannot project a 16 foot picture at the same distance, a screen which reflects evenly at a narrow angle cannot at the same time reflect evenly at a wide angle.

Third: Mirror Screens.—This surface consists of a sheet of plateglass, the back of which is coated precisely the same as is an ordinary plateglass mirror. After the back has been silvered, its face is ground to a dull finish, which is made rough or smooth, according to the conditions under which it is to work. The light is caught on the ground face, goes through, strikes the silver at the rear surface, and is reflected back to the rough finish. This has the effect of producing very high efficiency, or, in other words, a very high brilliancy for a given amount of projected light. The mirror screen is packed and shipped in a permanent frame, and is all ready to install when received.

A picture projected upon a plain lookingglass would not be visible to the eye because the polished surface will reflect to the eye rays from all points so located that a line drawn half way between the eye and the object and at right angles to another line drawn from the eye to the object will strike the mirror. Therefore since the picture comes from the lens, instead of an image of the picture you merely get a reflection of the bright spot light at the lens and an image of the auditorium, as a whole. In order that the picture become visible on the screen, it is necessary that diffuse reflection be substituted for direct reflection, or, in other words, that the picture light be "broken up," and this is accomplished by grinding the surface of the glass to a dull finish.

The manufacturer claims that the mirror screen produces two ideal results, viz: first, the surface may, within reasonable limits, be made with either large or small peaks and depressions, so that for a wide house the light is distributed at a wide angle, whereas with a narrow auditorium it is concentrated to a narrow viewing angle. Second, the surface is perfectly dull, without shine, and as a consequence only diffuse reflection is present, the same as on a dull, white wall, therefore a clear-cut, clean picture results.

To sum up matters pertaining to the mirror screen, it may be said that if the screen be properly selected with reference to local conditions high-class results should be obtained by its use. It is costly, but is in the nature of a permanent in-

vestment, since, barring highly improbable accident of breakage, it s to all intents and purposes indestructible, and once installed should require no attention whatever for many years, except an occasional cleaning, which is not at all difficult and consumes but little time. The mirror screen is peculiarly adapted for use in very long auditoriums because of the fact that a person with average eyesight will see a perfect picture even when several hundred feet away from a mirror screen.

Transparent Screens.—The transparent screen must be made of translucent material, so that the machine can be placed at its rear or back side and the picture be viewed by the audience in the auditorium *through* the screen. The image appears on both sides of the curtain, but appears "backward" to the operator.

The film is placed in the machine with the emulsion side toward the screen, instead of toward the light as in ordinary projection.

It is possible to use ordinary cheese cloth or thin muslin for this purpose, but if this is done the machine must of necessity be set lower than the screen and "shoot upward," nor can such a screen be used at all where there is a gallery in the theatre. The reason for this is that if any portion of the audience sit in such position that the eyes will be in line with any portion of the picture and the lens, they will see the bright lens spot through the screen.

The translucent screen, however, breaks up this bright spot and renders it invisible. If a cloth screen be used the result will be greatly improved if it is kept wet with water. The best screen for rear projection is ground glass, which lends itself particularly well to rear projection, because there is but slight loss of light, and furthermore the surface may be ground, fine or coarse as desired, in order to distribute at wide or narrow angles for a wide or narrow house. A fairly satisfactory transparent screen is made from tracing cloth, the worst difficulty being that it cannot be obtained sufficiently wide, and must of necessity contain a seam, which will show more or less in the picture in spite of anything one can do.

Rear projection is, however, not very much used. It presents advantages where conditions are such that it can be used properly, but in four cases out of five where it is attempted there is too short a throw to get the best results. In fact it is usually employed as a makeshift. Properly used, that is to say where the distance from machine to

screen will be such that an objective lens of not less than 4 inch E. F. will be required, rear projection on a glass or other high-class translucent screen comes pretty near being ideal, since the operating room, with its noise, heat and fire risk, is located entirely away from the audience, and presumably outside the theatre.

If this be done, and the operating room be located in a separate structure, it will be necessary to locate the screen in an opening in the theatre wall, and this opening must be protected by a sheet of plate glass, outside the screen, with the space between it and the screen closed in tightly to form a dead air space. Otherwise there is apt to be trouble with frost in winter. It is also necessary to protect the light ray from rain and snow if it shoots across an open air space. Rear projection is seldom employed under these conditions, however.

The question is often asked of the writer: Can we locate a transparent screen at the proscenium line, set the projector at the rear of the stage and get a good picture? The answer is no! It is never advisable to attempt the projection of a picture of a size suitable for theatre work with less than 50 feet from lens to screen, and 40 feet may be considered as an absolute minimum, understanding, however, that really high-class results cannot be had at 40 feet unless the picture be much smaller than is suitable for a theatre. Another objection to this plan is that it brings the front seats too close to the screen.

Eye Strain.—About thirty-five people in every hundred avoid the picture theatre either on account of eye strain or because they fear injury to their eyes. Eye strain in moving picture theatres may, broadly speaking, be attributel to four causes.

First (and greatest): **Flicker and Unsteady Light.**— In this case the retina of the eye expands and contracts so rapidly, in attempting to adapt itself to the changing light intensity of the screen, that the muscles of accommodation are subjected to terrific strain. This sort of eye strain is so obvious and so well understood that comment seems almost unnecessary. As light becomes stronger or weaker the pupil of the eye expands or contracts. It is nature's way of regulating the amount of light reaching the retina of the eye. When this change occurs continuously and rapidly, however, the strain is highly injurious. In this connection it may be said that in nine cases out of ten where there is an objectionable

flicker it can be eliminated, or at least very greatly reduced, if the operator understands his business, and is able to match his shutter-setting and width of blades to local conditions. The screen itself, as such, *never* produces flicker, but where a screen of comparatively low efficiency is used and a screen of the same area but of higher efficiency is installed *using the same amperage*, this tendency to flicker will be increased by reason of the added brilliancy of the light. The period of darkness remains the same, but the light is much more brilliant, hence there is increased contrast. If the brilliancy of the picture were reduced to its former value by cutting down the amperage, it would be found that the flicker would be neither greater nor less than it was before.

It may be stated as a fact, that, in this day of improved projection apparatus, a pronounced flicker is inexcusable. Either there is something wrong with the knowledge of the operator, with the condition the projector is working under, or the speed of projection is too slow.

Second: **Eye strain may be and is caused by lack of definition in the picture,** which, in turn, may be due to a dirty lens, a badly matched lens system, or to a poor objective, to poor condenser, or to fault inherent in the film itself. On this account it is of very great importance that lenses of good quality be used, that they be kept perfectly clean, and that the operator have his picture in absolute focus at all times. It is also important that manufacturers send out no film which, through inherent fault, cannot be projected with perfect sharpness. See Page 152.

Third: **Eye strain will be caused by poorly illuminated, indistinct or jumping pictures.** An intensely absorbing picture story will cause the audience to strain every effort to catch every phase, every word, every expression of the face and action of the artist on the screen. Sometimes an apt expression, though slight in detail, will change the entire meaning of what the actor seeks to portray. We try to see, and, by reason of dimness or "jumpiness" of this film, strain our eyes in the effort.

We read the picture story just as we do a book, and if we attempt to read a book in poor light or when it is shaking or moving, the result is strain upon the eye, which is entirely avoidable by simply moving into a better light and holding the book still. This is only a matter of plain common sense, and needs no argument in its support.

Precisely the same thing applies in projection, only instead of "moving into better light" we get the same effect by project-

ing more light to the screen, and instead of "holding the book still" we prevent the film from jumping.

Fourth: Eye strain is often caused by the use of too large a screen, with a portion of the seats placed too near it. For example: we breathe by unconscious motion, exactly as the eye automatically changes its position to focus itself upon the exact point we wish to see, without any special mental effort on our part. If we sit near a large screen the eye will naturally try to follow the film story, and in so doing will move all over the surface of the screen, moving continuously and very rapidly. Just imagine the gymnastics the eye is called upon to perform under such conditions. I venture the assertion that a glass eye would not stand up very long under that sort of treatment, much less the delicate organism of the human eye.

Flat Surfaces—Location.—It goes without saying that whatever the surface of the screen be composed of it should be perfectly true and flat, without wrinkles, bumps or uneven places; also it should be set as nearly as possible with its center level with and in line sidewise with the lens. This latter condition is not always practical of accomplishment, nor is an angle of projection which does not exceed 25 per cent (3 inches to the foot or 15 inches in 60) very seriously objectionable, though a side throw is highly so.

The practice of some large houses in placing the projection machine at the top of a very high gallery and angling down at about 45 degrees toward the screen is a very, very bad one. It causes keystone effect, and, even allowing that this may be eliminated by filling in the machine aperture, the distortion of the picture is still there and is not pleasing to the eye. Many attempt to compensate for this by leaning the top of the screen back a little, but if it is leaned much more than twelve inches from the perpendicular the appearance is unsatisfactory, especially from the main floor. Locating the operating room thus wrongly is usually due directly to the fact that the exhibitor refuses to sacrifice seating space on the main floor in a lower balcony. He prefers the permanent injury of his projection to the sacrifice of a few seats. The operating room could usually, by proper planning, be placed in a lower balcony or even on the main floor. The gain in excellence of projection would far more than compensate for the few seats lost. Its exterior walls could easily be decorated in such manner that its appearance would not be at all objectionable, and, in general, as I have said, the results would be far more satisfactory.

Tinted Screen Surfaces.—At this writing (last half of 1915) it is very much the fashion for screen manufacturers to tint the surface of their screens. Some manufacturers put out several surfaces, such as plain metallic, flesh tint, faint yellow, etc. *The author is not in accord with this practice.* While freely granting that tinting the surface of the screen may and probably will have the effect of softening the tone of the picture, still he does not believe there is anything so beautiful as the plain black and white projection, with a pure white light and as nearly as possible a pure white screen surface. The only tinting he believes in is the addition of a little blue to the white when mixing a screen paint or calcimine, this being for the purpose of rendering the white paint still more white, just as the laundryman adds bluing to the rinsing water in order to make the clothes more white. You will therefore see that this sort of tinting simply follows out the author's idea of making the screen as white as it is possible to get it.

Let it be noted, however, that I am willing to give due credit to the ideas and opinions of others, and in this matter simply express my own individual opinion.

Outlining the Picture.—It is wonderful what a difference in effect is produced by giving the picture a proper border or outline. There is nothing so effective for this as a soft, velvety black, such as is produced by ordinary dry lampblack, mixed with one-third linseed oil and two-thirds turpentine. This form of outline is shown in Fig. 69. In order to outline the picture thus proceed as follows: Get the light from both machines registered on the screen exactly where you want it, and then with the plain white light projected to the screen draw a pencil line about 2 inches inside the light all around, making the corners round, just as the light is on the screen. Now shut off the light and paint all the screen on the outside of the line black. This sort of outline adds very greatly to the brilliancy of the picture.

Where the black border is used there is not only less distraction for the eye, but the effect of added light brilliancy is had without its actuality. This is of very distinct advantage, since every increase in actual light brilliancy has a tendency to accentuate any tendency there may be to flicker. With very brilliant light and normal speed of the projector, even the more modern three-wing shutters do not entirely get rid of the flicker. By the use of a black outline the picture appears much more brilliant, owing to contrast,

whereas it actually remains exactly as it was, and thus the effect of added brilliancy is attained without flicker increase.

The black border cannot be used, however, where a stereopticon picture having a height greater than the height of the moving picture is to be projected on the same screen; also it must be remembered that *the paint for the border must be dull black—without any gloss at all.*

The reason for allowing the picture to lap over on the black is that it greatly minimizes the effect of any movement

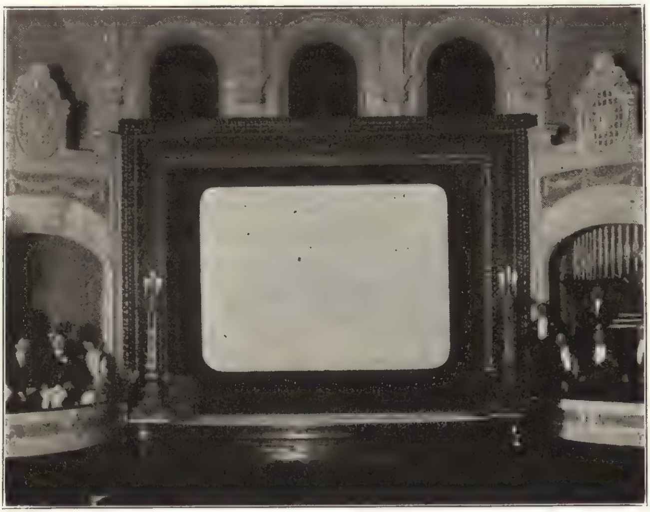


Figure 69.

of the picture on the screen; also it hides any vibration there may be in the machine aperture itself. Such vibration should not be present, but sometimes, owing to a poorly constructed operating room floor, it is.

Where the screen is set back on the stage the better plan is to outline the screen with black, as above set forth, and then from its outer edge stretch black cloth having a perfectly dull finish (velvet is best, though rather expensive), to the inside edge of the proscenium wall on both sides and above, thus forming a sort of funnel. If rightly done, the cloth preferably being in pleats or folds it is very effective,

and sets off the picture splendidly. The stage floor in front of the screen should also be painted dull black.

Black may be objected to as too somber and there is foundation for this objection. Black, however, is best from the projectional point of view, but other dark colors may be substituted, such as green, violet, lavender or old gold, and instead of forming a funnel a more or less elaborate arrangement or stage setting may be preferred. In fact the possible combinations are limitless, but *stick to dark colors,* with at least a two foot band of dead black next the picture.

Locating the Screen in Front of the House, *that is to say, at the end where the audience enters, with the operating room at the rear end of the auditorium, is bad practice, and unless required by local law should not for one moment be considered. The effect is bad in every way.*

Those entering and going out must perforce pass beside the screen, which has the effect of constantly distracting attention from the picture. The idea which has caused the lawmakers of some localities to enact ordinances requiring this sort of screen location is based on the view that in case of fire in the operating room the audience will not be obliged to pass near it and therefore will not become panic-stricken. That argument *sounds* very nice; also it looks well in print. The only fault that could possibly be found with it is that it doesn't work out in practice. If an operating room fire occurs with the operating room near the entrance of the theatre the audience hestitates to some extent to pass it, and is, to just that extent, deterred from making a rush, but if the operating room is located at the other end and a fire occurs, good night! Somebody yells fire: There is nothing in the world to stop them. They make one grand rush and pile up in a heap at the entrance. Result: many injured, and probably some killed. There is no earthly necessity for such laws, anyway. If the operating room be rightly constructed, equipped with a proper vent flue and has a properly arranged shutter system, you can burn several reels of film therein and the audience will never know there is a fire. *If our distinguished lawmakers would pay more attention to the proper arrangement of the vent flue and fire shutters of the operating room, and not so much to foolish ideas of this sort, it would be much better for all concerned.*

Where the screen is located on the stage and the house is a short one, say less than 75 feet in depth, it is much better to set the screen back as far as you can get it without

seriously interfering with the view from extreme side seats. Those in the rear will still be close enough to have an ideal view, while those in the front rows and at the side of the auditorium will have a vastly improved view over what it would be if the screen was at the proscenium line.

Where Vaudeville Is Used.—In many theatres where a mixed performance is given it is necessary that the screen be placed near the curtain line, in order that the stage may be set while the picture is being run. The majority of houses of this kind use a plain cloth drop, usually outlined in black. Such a screen will sway with every breeze, or will move when touched by stage hands working at its rear. A much better plan would be to frame this drop substantially, though lightly, and back it with light lumber. At either side grooves can be arranged so that the screen will always set precisely in the same spot when lowered, and will at all times be perfectly flat. All this is entirely practical, and should be carried out, though it, of course, applies only to houses having a fly loft. Such a screen would be tolerably heavy, but could easily be counterweighted to handle with perfect ease.

Height Above the Floor.—The height of the screen above the floor must be governed by circumstances, but where there is a stage I believe the general effect is best if the bottom of the picture be located quite near the stage floor. True, there is a distinct advantage in locating the picture high up on the wall, since it does away with the obstruction to the view caused by persons seated in front. Such a location, however, also has serious disadvantages, which, in my opinion, far more than outweigh the gain. The disadvantage is that the picture is not shown in the normal level position in which we are accustomed to look at such scenes in real life. It has, I think, a decided tendency to emphasize in our mind the fact that we are looking at a *picture,* and not a real performance. Everything considered, I believe that locating the bottom of the picture at as nearly as practical six feet above the auditorium will usually be best.

Size of Picture.—Much has been said, and many arguments have been advanced for and against the large and the small picture. The question is just as strongly debated today as it ever was. Personally, I do not believe there is or ever will be any set rule as to the picture size which can always be followed to advantage. The photograph, as projected through

the machine aperture, has very considerably less than one square inch of area. We therefore see that the magnification is, in any event, enormous, and we must remember that

Every defect in photography, every movement of the film, and every scratch mark and jump is magnified as the size of the picture is increased. Also we must remember that as the size of the picture is increased the light strength must also be rapidly increased, if the brilliancy of picture is to remain as it was.

You have a light strength produced by 30 amperes D. C., let us assume. You are projecting a 12 foot picture. This means that the light is distributed over 108 square feet of area. Suppose you increase the size to 16 feet. You now have 192 square feet of surface—almost double that of the 12 foot picture; hence the curtain brilliancy obtained from your light is decreased by almost one half. You must increase the amperage very greatly to secure illumination equal to that of the 12 foot picture. You will therefore see that a large picture is costly, in current consumption or in sacrifice of brilliancy. See Page 165. A 12 foot picture is considered as being "life size." A picture of this size is, to one of normal vision, perfectly distinct in all its details 75 or even 100 feet away, or much further if it be a mirror screen. It is seldom there is any real reason for projecting a larger picture, so far as ability of the audience to see the details of the picture be concerned. It must, however, be granted that in a large house a 12 foot picture seems somewhat out of proportion, especially if the screen be located on a large stage.

One other very important factor enters, viz: ability of those in the rear seats clearly to see the faces of the actors, this by reason of the fact that in the silent drama very much often depends upon facial expression. The glance of an eye or some movement of the features may change the whole meaning.

However, again no rule can be given which will apply to all cases. With a high grade lens and a perfectly sharp, brilliant picture these things are clearly discernible under conditions which would render them almost invisible with weak light or poor, "fuzzy" definition.

The size may be increased very greatly, but it is always at the expense before mentioned. The possible limit depends on local conditions, and how much you are willing to expend for current and good lenses; also mirror screens do not exceed 13½ by 18½ feet in size. For a throw of 50 feet, fifteen feet ought to be the limit, since with a wider picture optical

difficulties are encountered. A very short focal length projection lens is required to project a wide picture on a short throw, and such lenses seldom give sharp definition. With a throw of 75 feet, an 18-foot picture is as large as it is well to attempt. At 100 feet almost any size you can illuminate may be projected. To put the matter concisely, I do not advise the use of a projection lens of less than 4 inch equivalent focus. This matter will, however, be treated more exhaustively under "Lenses." Mr. Frank Rembusch, who has made a study of such matters, says:

"If a screen is too large, an elongation of faces and figures results, especially on a short throw, where the house is short. If the screen is too small the results also are not satisfactory. To some extent, of course, it is a matter of taste, but after consulting the best authorities, together with inquiries among lens manufacturers as to what can be done, I have arrived at the following opinion: A house 25 feet wide and 75 feet long should have a screen about 9 feet by 12 feet, and the longer or wider house in this proportion. For instance, a house 40 feet wide and 100 feet long should have about a 12 by 16 screen; a house 25 feet wide and 125 feet long should have about an 11.6 by 15.4 screen. No screen should be larger than 12 by 16, except where the first row of seats in front can be located at least 30 feet distant therefrom, and the throw is not less than 125 feet. Here is your limit.

"A larger screen will cause eye strain up close, and with a shorter throw will cause elongation of the faces and figures, and a distortion of the pictures."

Certainly friend Rembusch is rather extreme in his statement that it is not well to attempt the projection of a picture larger than 16 feet at less than 125 feet. I am of the opinion that a practically perfect 18-foot picture may be projected at 100 feet (5¼ inch E. F. lens), or even a little less. His other statements I agree with, however.

Coatings.—Many managers, particularly in the smaller towns, and, to some extent in the small theatres of the larger cities, prefer to use a home-made screen, which they construct of cloth, plaster, and occasionally of metal. I have already set forth the relative points of excellence as between the cloth, plaster, metallized and mirror surfaces, to which I will add the further remark that cloth, or plaster properly coated, gives as artistic a projection as it is possible to produce on any surface. The difference between it and the more costly screen is found in the fact that with the latter

surfaces much greater brilliancy is had for a given amperage than is possible with either cloth or plaster.

The traveling exhibitor, as a general proposition, uses an uncoated cloth "sheet," but where cloth is used in a permanent location it should be stretched very tightly on some sort of frame, coated with a size made by dissolving a good grade of glue in warm water. I do not remember the exact amount, but, at a guess, would say about one pound of good glue to an ordinary pailfull of water. When the sizing is thoroughly dry the screen may receive its final coating, which may be (a) white lead or zinc ground in oil (to be had at any paint store), mixed about in the proportion of one-fourth boiled linseed oil and three-fourths turpentine, to which has been added just a little ultramarine or prussian blue—not much, but just enough to give the paint a rather pronounced bluish tint *while in the pot.* It will look perfectly white on the screen. (b) One of the patent white calcimines, such as muralite, alabastine, etc., also to be had at any paint store. No matter whether paint or calcimine is used give the curtain two or three coats, rather than one heavy one, and be sure there are no brushmarks when the job is finished. After the final coat has dried, outline the screen in black, as already directed. See Page 178.

Where a plaster screen is used I would recommend that it be of cement finish, rather than ordinary hard coat, because the cement may be calcimined and the calcimine washed off and renewed many times without in any way affecting the underlying surface. The plaster or cement should be coated with one of the patent calcimines as before mentioned even though the surface be plaster. The calcimine will give a considerable better projection surface than will the plaster itself.

Caution.—*Do not imagine you can coat a cloth or plaster screen with calcimine or paint and use it indefinitely without doing anything more to it.*

I would very strongly recommend that where a plaster calcimine coated screen is used, it be washed off and recoated at least once every sixty days. It may *look* clean and bright, *but you may take it from me, it is not.* The wall paper or calcimine on the ceiling of your home may look perfectly clean, but rub your damp finger on it and see if it is; perhaps the result will astonish you. The same thing applies to the screen. Calcimine is cheap. My advice is to USE IT FREQUENTLY.

Paint may be washed, if it is carefully done, but it is not the same as new. I much prefer calcimine to paint on a plaster surface, but if paint is used, the plaster should be first thoroughly sized.

Caution.—*Don't attempt to make home-made metal surface screens by applying aluminum to cloth or plaster. There is about one chance in a hundred that you will get anything even approaching satisfactory results. Calcimine or paint is much better than ninety-nine out of every hundred home-made aluminum screens.*

THE DIFFERENT SCREENS

The Mirror Screen.—The salient points concerning the mirror surface made by the Mirror Screen Company, Shelbyville, Ind., have already been set forth. The screen is a high class article, and has many enthusiastic suporters among exhibitors. It gives a very brilliant picture per ampere of current used. It is expensive in first cost, but will last practically forever. *The surface must be very carefully selected with reference to the conditions under which it is to work.* For the long, narrow house, get a smooth finish, but for a wide house get it just as rough as possible. It comes all packed in a box, ready for installation. Its surface can be washed perfectly in a few moments. The silver backing is guaranteed against deterioration.

There are nine different mirror screen surfaces, designed for use in theatres of varying dimensions. Mirror screens have been in use in theatres for several years. Therefore they have been thoroughly tested as to their efficiency, and, as already stated, when properly selected with reference to local conditions results from them are excellent. They may be had in the following widths: 8 feet, 8 feet 8 inches, 9 feet 4 inches, 10 feet 8 inches, 11 feet 4 inches, 12 feet, 12 feet 8 inches, 13 feet 4 inches, 14 feet, 14 feet 8 inches, 15 feet 4 inches, 16 feet, 16 feet 8 inches, 17 feet, 17 feet 4 inches, 17 feet 8 inches, and 18 feet. The last four widths require slot cars for their shipment. They are made as small as required, but 8 feet is about the minimum used in theatrical work.

When exhibitors erect a theatre and contemplate installing a mirror screen they should remember that the screen must be brought in before the walls are closed in, as it is all in one piece. The 8-foot screen is 6 feet high, with probably a foot added to that for packing, and in an old house it may

be necessary to cut a slot in the wall, over a door or elsewhere, to get a mirror screen in.

The prices range from $135 for an 8-foot screen to $1,000 for the 18 footer.

The same company also manufactures metallic surface screens of various kinds, made of seamless cloth, and the surface is guaranteed against deterioration for a period of five years.

Simpson Solar Screen.—One of the oldest metallic surface screen surfaces on the market is the Simpson Solar Screen, manufactured by the Simpson Solar Screen Company, New York City. This surface is of pure, carefully selected aluminum. Each screen is hand-made, and the surface thus produced gives sharp contrast as between the whites and blacks; also it gives great brilliancy to the whites.

The screen is made in one piece up to twelve feet in width. The author can vouch for the excellence in results from this surface. It is guaranteed against peeling, tarnishing or other defect for a period of five years, and its manufacturers assure me that the guarantee will be made good.

The surface is slightly, though not heavily matte. The reflection is entirely diffuse, there being no direct reflection, therefore no haze.

The Mirroroid Screen.—The J. H. Genter Company, Newburgh, N. Y., manufactures the mirroroid screen, which is a product familiar to exhibitors pretty much all over the country. Mirroroid screens have a matte surface. The comparative matte of the various mirroroid surfaces is shown in Fig. 70, which is a full size photograph of samples of the material. In the opinion of the writer the rough surfaces are best adapted for use in wide houses, and it is his opinion that, whereas the matte or visible roughness of the surface has little or nothing to do with the actual diffusion of light, still it has a very beneficial effect in enabling the spectator who views the picture at a side angle to get a good detail of the picture. There is a distinct difference in the effect produced by the visible roughness of the matte surface, and in the effect produced by the invisible peaks and depressions before described. One produces light diffusion and the other gives detail to the picture when viewed from an angle, or, at least, that is my opinion. Each is of importance to perfect projection.

Mirroroid screens have given very general satisfaction, and can be recommended to the consideration of exhibitors who are looking for a good article. They come in a variety

of tints, such as plain "metallic surface," "silver white," "flesh" tint, etc., and the surfaces are guaranteed against deterioration for a period of five years. They are seamless up to about 11 feet wide and above that a special treatment tends to render the seam invisible.

Figure 70.

The Minusa.—The Minusa Cine Products Company, St. Louis, is putting out various types of metallic surfaces, its specialty being the Minusa Gold Fibre Screen. This company produces screens, some of which have very rough surfaces, as shown in Fig. 71, which is a full size photograph of samples submitted by the Minusa concern. These screens

are fully guaranteed for a period of five years against defective workmanship, discoloration, etc.

The Radium Gold Fibre Screen is one of the oldest and most widely advertised of the many so-called "patent" projection surfaces. Radium Gold Fibre is a metallized screen

Figure 71.

and is frankly sold as such, with all arguments both for and against the metallized projection surface kept constantly in mind by those who are marketing it. A high grade gold bronze is the basic ingredient of the surface coating, and the arguments for and against the use of yellow in projection surfaces are well known. Unquestionably the radium gold is

an excellent surface for those who favor a yellow-tinted surface. It is made by Radium Gold Fibre Screen, Inc., 220 West Forty-second Street, New York.

Stippled Surface.—The following is a scheme for which it seems H. E. Hammond, manager of the Crescent Theatre, Erie, Pa., is responsible. It is a new one and I only give it for what it is worth, with the remark that it looks very good. It has been reported on favorably by the operator who installed the projection plant in the Crescent.

Mix dry zinc (to be procured from any paint store) with water, making it as *thick as can be spread with a paint brush.* Then paint the plaster wall with the mixture, and follow up with a wide, flat brush, pouncing the wet surface with the ends of the bristles of the brush. Let it dry thoroughly. Apply a second coat and pounce in the same manner; let this dry and apply a third coat, again pouncing with the brush. The result is a flat surface, covered with little round craters, or depressions.

This ought to make a very white surface, and, moreover, the effect should be good. It is said that the picture shows up much better on a wide view where this surface is used.

Chalk Surface.—Still another surface has been favorably reported. It has in its favor the fact that it may be easily and cheaply tried out. It consists of rubbing any suitable surface thoroughly with ordinary white chalk, school crayon broken into pieces two inches long and used flatwise will do, but chalk such as mechanics use for chalk lines (obtainable at hardware stores) is much the best. It is said, and it sounds reasonable, that a picture projected on this surface stands out with great brilliance. You must, of course, get the chalk rubbed on evenly.

Fire-Proofing.—Any fabric may be fire-proofed by thoroughly saturating it with ammonia phosphate mixed in the proportion of one pound to one gallon of water. In the case of a cotton screen I would stretch it tightly on a frame, dissolve the phosphate in water and saturate the fabric thoroughly by using a new, cheap paint brush. Let it dry and, while it will char, it will not and cannot be made to blaze. A lighted match would char the fabric where it came in actual contact with it, but that would be all there would be to it—just a hole in the cloth. Phosphate of ammonia may be had of retail druggists at about 75 cents a pound; wholesale it is much cheaper. There is nothing in phosphate of ammonia that will injure the fabric. Wood soaked in

this solution is made thoroughly fire-proof in the sense that it cannot be made to blaze.

Stretching the Screen.—The Mirror Screen Company, which also manufactures metallic surface screens, suggests the use of a frame known as the "artist frame" for mounting moving picture metallic surface screens or cloth screens. Some years ago the mounting of a screen was of little importance. A cloth screen was mostly used, and due to low reflective power, uneveness or wrinkles therein were scarcely visible; moreover a thin cloth could be stretched taut on almost any kind of a frame. Of late, however, the wide use of metallic surface screens, many of which are on a heavy canvas, makes it necessary though very difficult to stretch them tightly, since with a semi-reflective surface every wrinkle or uneven place will show badly.

Figure 72.

There is nothing better adapted for this purpose than what is known as the "artist frame." It is much superior to any home-made arrangement, and may be purchased from almost any screen manufacturer for less than it would cost an exhibitor to make it. It is simple, and I believe quite satisfactory. It may be shipped K. D., and the process of putting it together is one which can be readily performed by any man of ordinary intelligence. Begin to put the frame together by laying it bottomside up, on a floor or other flat surface. After the corners are bolted together see that

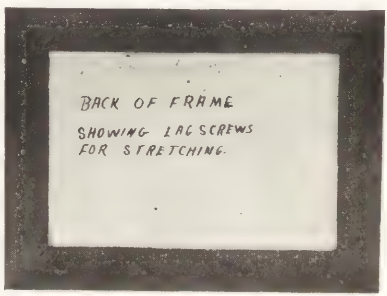


Figure 73.

every corner and the whole frame is exactly square. This may be tested by measuring diagonal corners. If the distance from diagonally opposite corners is equal the screen is square. Now put on the back braces and then turn the frame over or set upright in place. The various steps in the process are shown, in their order, in Fig. 74.

Putting on Cloth.—The cloth should be rolled up so that the edge that goes to the top unrolls first. It may be put on either with the frame standing up or laying down. Standing the frame upright is the best plan, however, because the cloth will partly stretch by its own weight, and the whole job will be more easily and better done. A good start insures success. Lay the roll of cloth on a level floor; unroll a foot or two, and stretch a chalk line to determine whether or not its edge is perfectly straight. Trim it, if necessary, to fit the chalkline. Now make a chalkline across near the extreme edge of the top of the frame, on the front side, where the cloth is to be tacked. The straight top edge of the cloth and the line on frame are placed together, and the cloth is tacked fast, thus insuring a good, straight start.

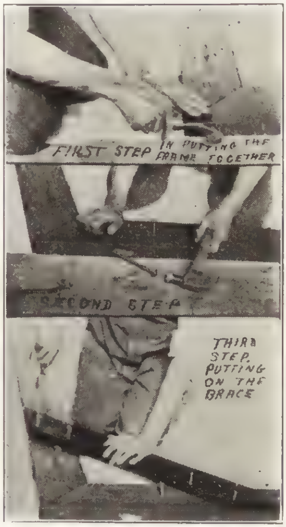


Figure 74.

Tacking on Cloth.—Place the tacks about two inches apart. A thin tack with a large, flat head is the best. If the frame is placed upright a piece of cheesecloth should be looped and nailed to the frame on each end, to hold the roll of cloth in position while the top edge is tacked in place. Start at the center of the top, and tack both ways along the chalk line, until within about three or four feet of the corner. A single tack will hold each corner in position until you are ready to tack corners. Now unroll cloth slowly and carefully, keeping it stretched at all times. Stretch and tack the bottom of screen, beginning at center and working again to within three or four feet of each corner. Now tack one side at center to within a short distance of corner, and then tack

and *stretch* the cloth on the other side, after which finish up the corners.

In tacking any cloth screen always begin at centers of each side and finish corners last.

If the work is done carefully the surfaces will be almost entirely free from wrinkles, and where a light cloth is used and well stretched by hand a very even surface is possible on a common hand-made frame. The artist frame we are describing is provided with finishing strips which are nailed to cover up the tacks and raw edge of the cloth, and this helps the appearance very much. Beveled *stretcher* strips are then pushed down between the cloth and frame from the back, giving the appearance of a bevel around the edge on the face side. This gives a handsome. finished appearance to the screen generally.

In most cases the cloth is free from wrinkles when the stretcher strips are put in position, but to provide for further stretching lag bolts are placed in the frame which, when screwed in, push out the stretcher strips still farther, so that the screen can be made as tight as a drumhead. The artist frame is always good property, as it can be used again for new cloth. Those exhibitors who use metallized screens should renew them at least every two years. Many metallic screen surfaces lose their brilliancy in even less time, and often those of inferior quality will become dull within a few months. Fig. 72 shows front of finished screen.

THE FILM

The film is a strip of celluloid 1⅜ inches wide, by from 5½ to 6 thousandths of an inch thick. In the process of making the celluloid is originally in strips about 2 feet wide by 250 to 300 feet in length. These wide strips are passed through a machine which spreads upon one side a coating (negative or positive, according to the use to which the stock being treated is to be put) of photographic emulsion, approximately one-thousandth of an inch in thickness, this being a part of the thickness of the film as above given.

After having received its emulsion coating the film is run through another machine, which splits it into ribbons 1⅜ inches wide, and these ribbons become the film stock which is purchased by the photoplay producer.

The negative stock is first perforated and then, as needed, is placed in a camera having an intermittent movement, revolving shutter and lens very similar in action to those of the projection machine (except that the mechanism is inclosed in

a light-tight box or casing), and each three-quarters of an inch of its length is successively exposed to light, and what is essentially a "snap shot" photograph impressed thereon at the rate of sixteen per second (that is to say sixteen per second is *supposed* to be the rate, but in practice camera speed varies considerably). After exposure the negative is developed, fixed and dried much the same as any ordinary kodak negative would be—the actual mechanical methods differ from the kodak film, of course, as the negative film will be more than 200 feet long, but the chemical action is precisely the same. The negative is then run through a projection machine so that the director may check up his work, make the scene over again, if necessary, or cut out any undesirable portions. When the negative is finally in acceptable form, it is placed in a printing machine in contact with a strip of positive film (positive and negative film are exactly the same, except that a different grade or kind of photographic emulsion is used), and by means of another intermittent movement and revolving shutter, but without a lens this time, is exposed to artificial light of known power, each picture being exposed for the small fraction of a second. The positive film is then developed, fixed and dried, after which it is sent to the assembling room, where the various scenes constituting a complete photoplay are arranged in sequence, joined together, the titles and sub-titles put in, and it becomes the "reel of film" with which we are all so familiar.

These, very briefly and crudely, are the processes a film goes through in the course of its making.

The perforating is usually done by the producer, though perforated stock may be bought from the film stock maker. There are 64 perforations to the foot on either side, or four to the picture. Film perforation is one of the most vexing problems with which the producer is confronted. Unless it be done with absolute accuracy there will be unsteadiness, and if the negative be unsteady in the camera, and the positive be unsteady in the projection machine, the effect is to magnify the slightest inaccuracy in workmanship and produce a very unsteady picture on the screen. Then, too, even with absolute mechanical accuracy in the perforating room, carelessness in the drying room may cause trouble, or inequality in thickness of film stock may cause uneven shrinkage, and again there is unsteadiness in the final result on the screen. It will thus be seen that those producers who are giving us films which give steady projection are entitled to much credit for their painstaking care.

Thickness of Film Stock.—Film stock should be of the full standard thickness, since thin stock has decided tendency to produce unsteadiness of the picture.

Standard Perforations.—*Perforations should, by all means, be of standard dimensions.* Instead of that there are several sizes and shapes, and since the projector sprocket teeth, which engage with these perforations, are of necessity of standard dimensions, more or less trouble is encountered from this source. At this time (Dec. 15, 1915) the Motion Picture Board of Trade has just formed a "Bureau of Standardization," the first work of which is expected to be the standardization of film perforations.

Damage to Film.—Naturally an article so thin and fragile as film is susceptible to damage. Film is easily torn in two; also it is easily scratched, particularly the emulsion. Its sprocket holes are subject to strain and to breaking and tearing. Most of the tearing is due to loose patches catching on sprocket idler rollers and to worn sprocket teeth and improperly adjusted projection machines. Nine-tenths of the scratching of film is due to poorly designed projector take-up tension and to "pulling down" in rewinding, the latter consisting in rewinding a portion of the reel loosely, then holding one reel stationary while revolving the other to tighten the film roll. Injury to sprocket holes is, in the main, chargeable to undercut and hooked sprocket teeth (see General Instruction No. 8, Page 462), and to too much pressure by the tension shoes of the projector. (See General Instruction No. 9, Page 463.)

Operators, are, I believe, as a rule, reasonably careful in handling film. In many theatres, however, rewinding, threading the machines and repairing film are made the duty of an irresponsible usher, or reel boy, and what he does to the film is all too often a shame to tell. Patches half and even three-quarters of an inch wide; patches without the emulsion scraped off, and patches as stiff as a board are too common to excite more than passing comment, and film spliced together with pins and even nails are often sent back to the exchange. It is an outrage, but one which cannot always be laid at the door of the operator. *Even when the operator does the rewinding and patching, he is, in all too many cases, expected to do it while projecting a picture, and hence must either neglect his projection or his rewinding and film repairing. IN THE MAJORITY OF CASES I BELIEVE THE REAL UNDERLYING FAULT LIES IN THE FAILURE OF THE*

THEATRE MANAGER TO EMPLOY SUFFICIENT COMPETENT HELP IN THE OPERATING ROOM. FILM REPAIRING SHOULD NEVER, UNDER ANY CIRCUMSTANCES, BE LEFT TO USHERS, BOYS, OR TO ANY OTHER THAN THOROUGHLY COMPETENT, RESPONSIBLE HELP.

Injury to the film in passing through the modern motion picture mechanism is invariably due to either the bad condition of the film itself, or to the laziness, carelessness or lack of knowledge of the operator, or to the *false economy of managers* who refuse necessary repairs to the machine. THE EXCHANGE MANAGER SEEMS, IN ALL TOO MANY CASES, NOT TO REALIZE THAT SENDING OUT A FILM IN BAD CONDITION IS NOT ONLY AN OUTRAGE AGAINST THE PRODUCER, AGAINST THE OPERATOR WHO MUST RUN IT, AGAINST THE THEATRE MANAGER WHO IS PAYING FOR FILMS IN GOOD REPAIR AND AGAINST THE AUDIENCE WHICH PAYS MONEY TO SEE AT LEAST A REASONABLY PERFECT PERFORMANCE, BUT IT IS A DIRECT INVITATION TO MORE AND GREATER DAMAGE, SINCE A LOOSE SPLICE IS LIKELY TO CATCH ON A SPROCKET IDLER AND SPLIT ANYWHERE FROM ONE TO THREE OR FOUR FEET OF FILM BEFORE THE TROUBLE IS NOTICED, ESPECIALLY IN HOUSES WHERE THE OPERATOR IS OBLIGED TO REWIND AND DO OTHER STUNTS WHILE HIS MACHINES ARE RUNNING. Patches in which sprocket holes are not properly matched will climb the sprocket teeth, causing the loss of a loop, or will grip the teeth of the sprocket and wrap around it. Split sprocket holes will catch on an idler and a section of the edge of the film will be split off, if nothing worse.

Emulsion deposits on tension shoes (See General Instruction No. 10, Page 464) often does considerable damage to first run film.

Mending the Film, i. e., making patches in it, is a matter which is of the utmost importance. Badly made patches are the cause of unending annoyance, as well as immense damage to the film itself.

If the patch be made in such manner that the sprocket holes do not match perfectly there is likely to be a jump of the picture on the screen as the patch goes over the intermittent sprocket teeth, due to the fact that the hole is too small to allow the sprocket tooth seating properly therein. There is also the liability of (a) the hole locking on the upper sprocket tooth and pulling the loop around under the sprocket. (b) The film running off the sprocket. (c) The intermittent sprocket climbing one or more holes, thus shortening one of the loops, making the other proportion-

ately longer and throwing the picture out of frame. (d) The takeup tension pulling the film over the lower sprocket, thus losing the lower loop. All this is liable to occur also where one of the holes is properly matched, but the other is not, thus making one hole small and making the film, as a whole, crooked at that point. You will see, therefore, the importance of matching the sprocket holes perfectly.

In the operating room it is customary to make patches with the fingers. Film cement welds more than it glues the film together. Considerable pressure is therefore necessary to make a perfect joint; much more than can be given by the fingers alone. Also with the fingers the pressure cannot possibly be applied evenly. Until recently there has been no film mender suitable for use in the operating room.

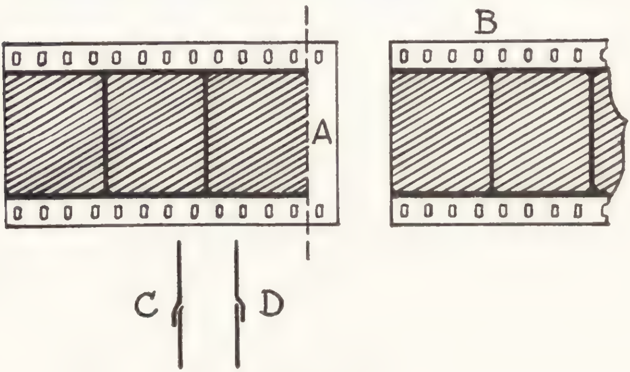


Figure 75.

To Make a Patch cut the film, as shown in Fig. 75, leaving a stub as shown at A. This stub should be not less than one-eighth inch and not more than three-sixteenths of an inch in length. The latter measurement is best, as it will be found difficult for the operator, usually working in a hurry, to make a good patch only one-eighth inch wide; but if wider than three-sixteenths the patch will be stiff. End B should be cut exactly on the dividing line between two pictures. Scrape every particle of emulsion off stub end A, and scrape about one-eighth inch on celluloid side of end B, to roughen the celluloid and remove all dirt and grease. A very sharp knife is best to scrape with. Some use the blade

of a safety razor. Be sure to thoroughly scrape end B and to scrape every particle of the emulsion off stub end, A. Cement will not stick to emulsion. You must remember that the emulsion covers the entire film on one side, therefore be careful to get it all off around the sprocket holes. This is where many make their error in patching film. They scrape the center of the stub and the center of the back of end B, but do not scrape thoroughly around the sprocket holes, *where the greatest strain will come.* In consequence their patches soon come loose around the sprocket holes and there is trouble. The stub should be scraped to a straight line, as per dotted line, else there will be a flash of white light on the screen as the patch passes. It matters little whether patches be made as per C, or D, Fig. 75. Patches made one way will go through some projectors better when partly loose, and through other projectors loose patches will go through if made the other way. If the patch is in good condition it will go through equally well either way it is made.

Having scraped the ends clean, as directed, place them together so that the sprocket holes exactly match (if patch is to be made with fingers), with the emulsion side of both ends either up or down—that is to say, on the same side. Grasp one edge firmly with thumb and finger and apply cement, with the cement bottle brush, to the other. Clamp the cement edge down tightly, being careful the sprocket holes exactly match, with thumb and finger of other hand releasing opposite edge. Apply cement to other edge and clamp that also, applying all the pressure you can for about ten seconds or so, and the patch is done. Every cement bottle should have a small brush attached to the under side of its cork. When you buy cement accept none without the brush. It is put up that way now by many, and should be by all.

Film Cement may be easily made. The following are a few formulas: For non-inflammable stock, one-half pound of acetic ether, one-quarter pound of acetone merch, in which dissolve six feet of non-inflammable film from which the emulsion has been removed.

For inflammable film, a piece of film three inches long dissolved in one ounce of acetic ether is a satisfactory cement, but it will not work on N. I. (non-inflammable) stock. In dissolving the film, in either case, first remove the emulsion and then cut the film into fine strips.

Acetone Cement.—Four ounces of acetone; one-half ounce ether; six inches old film, from which remove the emulsion and cut into strips.

Another Formula.—Equal parts of amyl acetate and acetone. Will not turn white on film, and will not dissolve the film as ether will. Works on all kinds of stock. Best used with an all steel three flap film mender. Can be used by those making patches by hand if worked rapidly. Scrape film, use small camel hair brush; keep bottle tightly corked when not in use.

Still Another.—One ounce collodion; one ounce banana oil or bronzing liquid; one-half ounce ether. For Pathe hand colored films, one-half acetone and one-half ether.

N. I. Cement.—For non-inflammable film add one part glacial acetic acid to four parts of flexible collodion or to any of the film cements. It is satisfactory for either N. I. or regular film.

Please understand that these are formulas sent in by operators from time to time, and recommended by them. The author does not vouch for their excellence.

Size of Reels.—There has been some inclination to increase the size of reels to two and even three thousand feet, which is, I think, bad practice. With two projectors there is really no good reason why it should be done, and it is distinctly objectionable for several reasons, one of which is that it increases the probable loss should a fire occur, as well as increasing the volume of fire and smoke.

One thousand feet of film has been and should continue to be the standard reel of film. It is convenient to handle, not overly heavy, and keeps the fire damage risk within reasonable limits. But the *reels themselves* should be not less than 12 inches in diameter. Personally, I believe a 14-inch reel having a 4-inch hub would be ideal from any and every point of view. *The hubs of present reels are too small.* Small hubs and the old-style takeup tension are a combination which produce heavy strain on the first fifty to one hundred feet of film. But whatever is done in that direction, *the reel should be of sufficient diameter that one thousand feet of the thickest film (yes, film stock varies slightly in thickness) will fill it to only within one-half inch of its outer diameter,* assuming the film to be wound not too tightly. Thus the whole film will be protected by the metal sides of the reel.

Overloading reels has been the source of much annoyance to operators in the past, but it is not so much practiced of late. Apparently even the exchanges are slowly learning to exercise a little common sense, in some directions at least, in the care of their property. The evil of the overloaded reel is threefold: (a) That portion of the film outside, or above the sides of the reels is absolutely unprotected, therefore liable to injury in many ways; also it is likely to slip off, to the exasperation of the operator and possible delay of the show while it is wound on again, to say nothing of probable damage through contact with the more or less dusty, dirty floor. (b) The increased temptation to "pull down," and pull down good and hard, too, to get as much of the film inside the reel as possible, and (c) The fact that the film may rub against the magazine, thus scratching the film, and possibly interfering with the operation of the takeup, incidentally requiring a very tight takeup tension, which is bad indeed, and a prolific source of damage to the first part of the film through scratching and pulling out the lower loop.

Leader and Tail Piece.—It is for several reasons essential that there be a "leader" and an opaque tail-piece on every reel of film, including multiple-reel features. In the first place, the leader protects the title from damage. In threading into the takeup it is frequently desirable, if not necessary, to fold an inch or so of the end of the film over on itself. By so doing it is made stiffer and is more easily thrust under the reel-spring. This means that the leader will occasionally break where it is folded; hence there will be gradual wasting away. If this occurs on the title the damage is quite evident. Soon there will have to be a new title provided. If, however, it is only a leader that is being thus damaged, it is not serious. But there is another reason why leaders should be used, viz., in rewinding, when the job is done, the end of the film often flaps around anywhere from one to a dozen times before the reel stops revolving, and if there be no leader to receive the brunt of this rough treatment, the title is injured. There is yet another reason which not only deals with the necessity for leaders, but also with their length. About 30 inches of film is required to thread into the takeup.

If there be not enough leader, the title will be practically all on the takeup side of the machine aperture when threading is completed. In order that the run may commence with the first image of the title it is necessary that there be not less than 30 inches of leader. If the title be short, even this is

not sufficient. If a short title comes on the instant the machine starts it will be gone before the operator can frame up and adjust his light, unless the film be threaded in frame on the first title picture, or the leader be a blank which has been exposed in the printing machine and developed, thus leaving only the dividing lines, which may be used as a guide in framing.

As a matter of fact, leaders should be of exposed film, developed very dense, and at least full four feet in length. This would give the operator time to frame up, adjust his light and have everything just right when the title comes on. Under these conditions if the machine be run slowly at the start the title would have to be very short indeed if the audience could not read it. As a substitute many houses show a stereopticon title slide before running the reel. I do not fancy this scheme. It savors of a makeshift. If things are as they should be there will be no necessity for a slide title, but in many cases it is unavoidable, and therefore better than nothing.

"Ah ha!" I think I hear some of you say; "you condemn the operator who does not thread in frame, yet now advise the use of leader which will allow of framing up after the machine has been started."

Right you are, brother, but I don't make conditions. None but Mr. Sloppy Workman Operator will thread his machine out of frame, and frame after it has started, but unfortunately Mr. S. W. Operator is still a numerous tribe, and we must therefore take that fact into consideration and try to fix things so that his sloppyness (a crude term, I grant you—but *expressive*) will do the least possible amount of harm.

The reason for also advising leader and tailpiece on multiple-reel features lies in the fact that they will only slightly inconvenience the operator in the two-machine house, and will be a great convenience to the one-machine house operator.

I strongly advise managers to insist on leaders not less than 48 inches in length on all films; also that they be, if possible, of the kind showing dividing lines. If exchanges will not supply such leaders it will pay theater managers to buy blank film and use leaders of their own.

It is important that there be a tailpiece on every film. It need not exceed 12 inches in length, but should by all means be there and should be of the opaque variety. When the light is shut off by the tailpiece the machine should be instantly stopped. Many operators have a most reprehensible

habit of running the machine until the end of the film has passed over the aperture and the white light is on the screen. This instantly destroys all the illusion. It is in the nature of a most unpleasant shock, particularly if the audience be deeply interested in the picture.

Stop your machine while the tailpiece is over the aperture. If there be no tailpiece, stop the machine when the end of the film comes out of the upper magazine, before it has got past the aperture. Never, under any circumstances, allow white light to show on the screen. SUCH WORK IS CRUDE IN THE EXTREME.

Inspection.—The operator should, so far as possible, repair all the damage he himself inflicts upon a film while it is in his possession.

However, *it is the duty of the film exchange thoroughly to inspect all films as they are received from theatres, and put them in A1 condition before they are again sent out.*

WHERE FILMS ARE USED IN CIRCUIT IT SHOULD BE A POINT OF HONOR WITH EACH OPERATOR TO SEND THE FILMS AWAY IN AS GOOD CONDITION AS THEY WERE RECEIVED. DON'T *leave it to your brother operator who gets them next, to repair the damage you do. You are in position to "pass the buck," true, but* IT IS NOT A VERY MANLY THING TO DO.

Perfect projection is impossible where a film is in imperfect condition, and a film is not in perfect condition when it has wide, stiff, or loose patches, misframes, ripped sprocket holes, etc. These faults are prolific sources of imperfection in projection.

It is a well known fact that many film exchanges make but the most superficial inspection of film and all too frequently no repairs at all. The underlying cause of poor inspection and repair of films is, I believe, the endeavor on the part of exchanges to get too much work out of a film, as well as an unwillingness to expend the proper amount of money in the employment of enough and competent inspectors. In many exchanges men or girl inspectors are employed, at low wages, and are expected to "inspect" anywhere from fifty to seventy-five reels of film a day, which is from two to five times (dependent on condition) as many as they can inspect and repair properly.

In such exchanges the inspection very largely consists in running a film from one reel to another at top speed. The only faults ordinarily detected by this sort of performance are the very bad ones, such as long strings of ripped sprocket holes, a patch loose half way across the film, or the film torn entirely in two. MINOR FAULTS CANNOT POSSIBLY BE

DETECTED BY ANY SUCH WHIRLWIND INSPECTION. It is a known fact, and a most reprehensible practice, too, that exchange managers will often ship reels out to exhibitors without any inspection at all. This practice is often aggravated by the exhibitor, who, when in a hurry for reels, demands that they be given him without waiting for any inspection at all. It is also a fact that exhibitors who do this will frequently upbraid the exchange if the films are in bad condition, and will blame the operator if breaks occur and the show is stopped. When a film leaves the exchange in anything but the best possible condition a wrong is done to everybody concerned, from the producer to the theatre audience. The result of faulty exchange inspection is, so far as the operator be concerned, one of two things: either it falls to him to do a lot of work which is no part of his duty and for which he is not paid, inspecting the films and putting them into condition, or, as an alternative, the projection, and incidentally his reputation as an operator will suffer.

I am well aware that the question of inspection and repair presents a problem of many angles, and one not at all easy to adjust. However, this I can say without fear of successful contradiction: there is absolutely no excuse whatsoever for the utterly miserable condition in which many films are received by the operator.

I am heartily in favor of operators demanding overtime for inspecting and repairing film when they are received in bad condition. It most emphatically is NOT *a part of their duty, and by what process of reasoning a theatre manager justifies his demand that his operator, without any remuneration whatever, do the work of an exchange inspector, I have never been able to understand.*

There is now on the market a film-fault detector, the invention of one Rosenfeld, through which a film may be run at tolerably high speed, and which will automatically detect all loose, wide or stiff patches, mis-frames, and other mechanical defects. This machine also has an appliance for making a patch, which joins the film properly, and insures a splice of uniform width from which the emulsion has been entirely scraped. It also at the same time cleans the film by passing it through a bath of chemicals and washing it with brushes. With such a device in existence there is no longer any excuse whatever for the mechanical faults found, in greater or less amount, in nine out of ten films sent out by the average exchange.

There is now on the market a neat little cutting plier with which broken sprocket holes may be notched as per Fig. 76.

This is a tool which should be in the hands of every exchange inspector and operator. It is the invention of A.

Figure 76.

Jay Smith, Cleveland. The price is $2 and well worth it.

Where to Keep Films.—Film should be kept near the floor of the operating room, since near the ceiling it is much warmer. It should be kept in a metal box having compartments for each reel, and one compartment below to hold a wet sponge or water. The film should be treated with a little glycerine once in a while, but this is only accomplished by having the film in actual contact with the liquid, as per directions further on. The glycerine is for the purpose of keeping the film soft and pliable, which it does by reason of the fact that it has the property of rapidly absorbing moisture.

Should water, by any accident, be spilled over a reel of film, or it even be dropped in a pail of water, it may be saved from damage if unrolled very quickly, not allowing the emulsion, which will be quickly softened, to touch anything. But the unrolling must be done very quickly or the emulsion will stick to the back of the film and pull off. This does not apply to colored or tinted film, though even these may sometimes be saved by very prompt action. The writer once rescued a first-run film from destruction thus: He happened to be in the operating room after the show had closed for the night. In taking the last reel from the magazine it slipped from the operator's hands and landed in a pail of water, being practically submerged. He grabbed the reel, ran down stairs, handed the end to an usher, ran to the front end of the theatre, looped the film over a chairback, and ran back and forth until the whole film lay across the back

of the seats. The emulsion became very soft in places, but next morning it was found that a total of less than five feet was damaged. The exchange men never knew of the occurrence until more than a month after, when they were told of it.

Moistening Dry Film.—Traveling exhibitors often find that a reel which has been a long time in use has become very dry and brittle. It may be remoistened and rendered pliable by unwinding into a large metal can, in the bottom of which water has been placed, with a wire screen over it to keep the film from contact therewith. Cover tightly, set in a moderately warm place until the film is soft and pliable. Watch closely, however, since if made too moist the emulsion will stick to the back of the film when it is rewound.

It is even possible to give a film a glycerine bath, as follows: In a long, shallow pan place a solution of 30 parts of clear water to one part of glycerine. Make a drum of slats about six feet in diameter by about six feet long (for one thousand feet of film), and by revolving the drum draw the film very slowly through the liquid, winding on the drum with the emulsion side out. After the film is all on the drum, revolve it rapidly to throw off the surplus liquid, then continue to revolve the drum slowly until the film is dry. It should not be used for two or three days. Perform this operation in a room entirely free from dust, or you may seriously injure your film.

Due to lack of proper inspection it is usually advisable, where practical, to inspect the films at the theater before they are run. To do this place the reel on rewinder, and rewind it very slowly, holding the edges between the thumb and forefinger with pressure enough to cup it slightly. By so doing you instantly detect all stiff or loose patches. Cut out the stiff ones and remake. Cement all loose patches and notch all split sprocket holes. If more than two sprocket holes are missing on one side—that is, in succession, of course—cut the film and make a patch. Inspection pays, and an ounce of prevention is worth a pound of cure. Managers, however, should not expect operators to inspect films for nothing. Such work is no part of an operator's duty and should by all means be paid for, aside from the operator's regular salary.

Stretched Film.—Ignorance, poor judgment, or carelessness in the drying room or the use of wrongly designed drying racks or drums is also responsible for much trouble. Film

which is wound tightly on an unyielding drying rack or drum will in all probability be badly stretched, and in consequence the picture on the screen will be unsteady. This fault usually may be detected by doubling two or three feet of the film back on itself, matching two sprocket holes and then seeing if the rest match. *Stretched film will not fit the projector sprockets properly, hence will not produce a steady picture on the screen.*

Operators using first-run film will often notice a tendency of the film to curl up, or "cup" edgewise, with a flat spot every few inches when the film is unrolled loosely. This is evidence that it has been dried on a drum covered with slats spaced as far apart as the flat spots occur. Such film will have a tendency to buckle more or less over the aperture plate, producing an in-and-out-of-focus effect on the screen. The buckling may or may not be sufficient to be readily detected in the picture, but it is pretty sure to be present in some degree where such film is used, and even though you cannot detect a distinct change in the definition of the picture (the flat spots are usually not more than 6 inches apart, therefore the effect is too nearly continuous to be readily detected by the eye as a separate phenomena every time a flat spot goes through) each time a flat spot passes the aperture, the effect is there and manifests itself by an injury to the sharpness of the picture. See "effect of loss of definition," Page 152. From what I have learned from some of the oldest drying-room men in the business, film should not be dried on a drying frame, but be wound on a large drum, having round-face slats not to exceed one-half inch wide, spaced not more than two inches center to center, or, better yet, though the process of drying would be slower, the face of the drum covered solid. In either case the drum should be so made that as the film shrinks in drying the diameter of the drum will be decreased against the pressure of springs.

I am not a film producer or drying-room man, but the foregoing seems to be *based in common sense.* It appears reasonable on the face of it. There is no manner of question but that film *is* often stretched in drying, and that the alternate cupping and flat spots are often present. Also there is no manner of doubt but that these things cause more or less trouble when the film is projected. If the producer disputes the correctness of what is herein set forth, let him set forth better reasons for the stretching and the cupping

and flat spots, and then, since he will be convicted of knowledge of the cause, *let him produce and apply the remedy.*

Emulsion May Be Removed from Film by soaking the film in warm water, to which ordinary washing soda has been added. Put in large double handfull of soda to the bucket of water. Wash the film afterward in clean, warm water.

CLEANING FILM

Cleaning film is an exceedingly important item in projection. The rain marks you see are nothing more or less than slight scratches in the emulsion, which may or may not have removed that part of the silver carrying the image, but which have filled up with dirt, thus becoming either opaque or semi-opaque. With this dirt removed these scratches would for the most part be invisible, or nearly so. I have seen a piece of film which was in literally terrible condition with reference to rain marks projected after a *thorough* cleaning, and it was almost like a first run.

Figure 77.

Cleaning films with liquids, however, is not a thing to be undertaken without proper knowledge. Alcohol will remove the dirt, and will not injure the emulsion, but it is likely to cause the film to curl very badly, therefore it is not to be recommended for film cleaning.

There are now on the market two film cleaning fluids which have the approval and indorsement of the Projection Department of the *Moving Picture World.* These fluids have been thoroughly tested by the department editor. The film can be washed in these chemicals without injury. They do not cause the film to curl, and do in every way a satisfactory job. One of these cleaners is made by the Githeil Company, New York City, and the other by the William Rhodes Film Company, Hartford, Conn.

A less thorough method of film cleaning, but one more readily applicable, is found in the Mortimer Film Cleaner, illustrated in Fig. 77. This cleaner is designed to be fastened to the rewinding table between the reels. It opens on

a hinge, and the film is drawn between two felt pads. This cleaner serves more than one purpose. It removes a considerable quantity of dust and oil, and by so doing improves the projection. It also detects loose patches and as a rule pulls them in two, which is much better than having them pulled in two in the projector, thus stopping the show. If this little cleaner were used continuously in all theatres it would do much to improve results on the screen, but in order to get the greatest amount of benefit from a device of this kind the film must be subjected to the process continuously; that is to say, at each rewinding. Results would also be improved if one of the cleaning fluids named were used in conjunction with the Mortimer Cleaner.

Another excellent device for cleaning film is the Ideal Film Cleaner, shown in Fig. 78. This device consists of base casting D, carrying arm A upon which are mounted spools B-B. Upon each of these spools is wound a strip of cotton flannel 9 feet long.

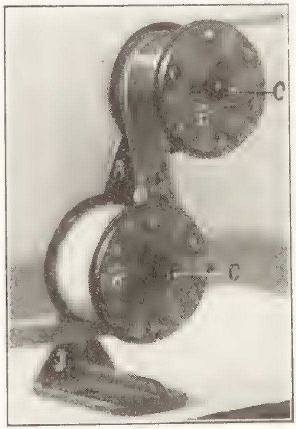


Figure 78.

The way the film passes through the machine is very clearly shown. Arm A is carried at its lower end by a spindle attached to the upper end of base casting D, and is held in upright position by a coil spring, so that when the rewinder is started with a sudden jerk or from any other cause the tension becomes too great the upper spool is pulled down slightly against the pressure of the spring, thus lessening the tension on the film. Under screws C-C is a coil spring which holds spools B-B over against arm A. In the caps of the other end of spools B-B are six holes similar to those seen in front caps, and one of these holes engages with a dowel pin in arm A. When a section of the cloth becomes soiled all that is necessary to bring a new strip into place is to pull outward on either one of the spools against the pressure of the coil spring, which releases the spool from the dowel pin, whereupon you can revolve it and

bring a new surface of cloth against the film, snipping off the soiled piece with a pair of shears.

I think the action of the device is made clear by this explanation and the photograph. Both the Ideal and Mortimer have the approval of the Projection Department of the *Moving Picture World,* and one of these devices ought to be in every operating room, since it will be worth its price merely for the removing of oil from the film.

CLEANING MACHINE AFTER FILM FIRE

Burning film leaves a sticky, brown colored gummy sediment on metal. This may be instantly removed by washing with ordinary peroxide of hydrogen, which may be had in 25 cent bottles at any drug store.

THE LIFE OF FILM

There have been many inquiries with regard to the "life of film," that is to say, those interested have wanted to know the length of time a negative or positive print could be preserved in usable form. The only authentic information I have been able to obtain is contained in the following excerpts from letters received from the Eastman Kodak Company, the Vitagraph Company, and the Lubin Manufacturing Company. The Eastman Kodak Company says:

"We cannot give you information which could be considered as absolutely authentic, but from the experience we have had we believe it is possible to keep processed film, both negative and positive, with but slight fear of deterioration, provided the proper amount of precaution be used. In the the first place *it is absolutely imperative that all traces of the hypo be removed in the developing process before the film is dried;* secondly, there should be no contact with any metal in any way, either by being wound on a metal reel or stored in the usual tin containers. The film should be tightly wound and then wrapped in tissue paper, with an additional oil tissue outer wrapping, and then placed in a wooden box, which in turn may be stored in a vault or safe, or placed where the atmosphere is of normal temperature and humidity. It might be well in winding the film to see that no unusual amount of moisture is wound into it. This small amount of information is about all we have on the subject, but if the foregoing be carefully carried out there is every reason to believe that

the film will remain in a state of excellent preservation for years."

Mr. J. Stuart Blackton of the Vitagraph Company says: "On the fourth of July four years ago our New York office was burned, and all the old films we had been keeping in a large iron safe, in hermetically sealed boxes, were destroyed. It is my opinion, however, that films of the present make, if sealed up in air tight boxes, would keep for a very long time. However, all the films over ten years old that I have seen and tried to run on a machine were very brittle and in such bad shape that it was almost impossible to keep the picture on the screen, this being due, no doubt, to the fact that they had not been kept from contact with the atmosphere."

Mr. Siegmund Lubin, president of the Lubin Manufacturing Company, says: "So far as the writer knows, a negative will keep indefinitely; that is to say, the way we keep negatives, viz: by winding them in small rolls, placed in small cans having lids. We have found negatives which we have had sixteen, seventeen and eighteen years to be in practically the same condition now as when they were taken, with a possible exception that they might be a trifle darker, though not enough to affect the negatives seriously."

This seems to be, up to date, the only available information. It comes from gentlemen who are perhaps best competent of judging, but even they are uncertain as to the exact facts, only one advocating hermetically sealing.

I would presume that the advice of the Eastman Kodak Company with reference to the method of packing would be best. They are in the film manufacturing business, and may be presumed to have superior knowledge of the best method of treating their own product. I might add to this by saying that I have myself seen film which was fully ten years old, and which had received no particular special treatment, yet seemed to be as pliable and in as good condition as the day it was made.

Summing up the whole matter, my own belief is that at or near sea level, where the atmosphere contains the ordinary amount of humidity, films packed according to the suggestion of the Eastman Kodak Company would keep in practically perfect condition for at least fifteen years; beyond that it would be merely a matter of speculation. However, the caution with regard to thorough washing out of the hypo is highly important. The least trace of hypo would, in the course of years, cause stains which would ruin the picture.

MEASURING FILM

The Edison, Power, Simplex, Motiograph, Standard and Baird projection machines all pass exactly one foot of film to each turn of the crank, so that the number of feet in a reel may be measured by running it through one of these machines and counting the number of turns of the crank, which will equal the number of feet in a reel.

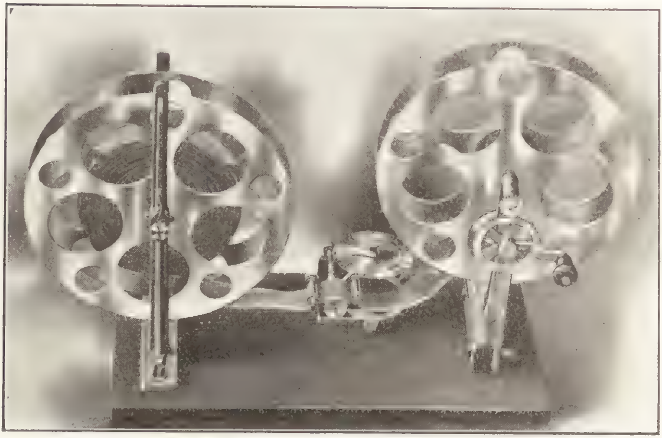


Figure 79.

In Fig. 79 a film-measuring machine is shown; the picture is self explanatory. This particular machine is made by the Nicholas Power Company. Several American makes of film measurers are on the market as well as instruments of English and French manufacture.

A very good film measurer may be made by disconnecting the intermittent of a standard projector, using only the upper sprocket—one turn of the crank, one foot of film.

The Operating Room

MORE and more the moving picture theatre owners and managers are coming to recognize the proposition that not only is it necessary to good results that the operating room be equipped with up-to-date appliances, but also that the room itself be commodious, carefully constructed,

and supplied with running water, as well as with thorough ventilation. The following may be taken as the essentials of a first class, up-to-date operating room:

1. It should be located central, sidewise, with regard to the screen, and as nearly as possible so that its floor will be 3 feet below the level of the center of the screen, though a considerable pitch in projection will not seriously mar the effect.

2. It should not be placed nearer to the screen than 50 feet, and may be placed as far away as 250, or even 300 feet, though 125 should be the maximum, since above that distance it becomes difficult to match up the optical system of the projector so as to give the best possible results for the power consumed.

3. It should be absolutely fire-proof in every respect, hollow tile, concrete or brick being the best materials for the construction of the walls and ceiling, and concrete with cement finish best for the floor. Asbestos millboard on a substantial angle-iron frame makes a fairly good room, if properly constructed, though it does not compare at all favorably with concrete, brick or hollow tile. One objection to this form of construction is that it is very far from being sound-proof, so that a noisy economizer or projector, rewinder, or even talking in the operating room is apt to be annoying to the audience. Rooms of this kind should have double walls and ceiling, separated by an air space. When the walls are of concrete or hollow tile I would strongly recommend that the ceiling be of the same material.

4. It must have a solid foundation, since the least vibration in the floor will inevitably affect the picture on the screen. You absolutely cannot have a shaky operating room floor and a steady picture on the screen.

5. It should be as nearly as possible sound-proof, to the end that the noise of the machines, rewinding, or anything else that goes on in the operating room will not annoy the audience. This is of much importance.

6. It should be provided with sufficient incandescent lights, arranged to instantly and brilliantly illuminate all parts of the room; also there should be an extension cord, with a lamp, provided with a guard, which may be carried to any point in the room.

7. It should be reasonably easy of access, preferably not opening directly into the auditorium, and should be reached by a stairway, rather than by a ladder. If it opens directly

into the auditorium, then the stairway or ladder should be surrounded by some sort of partition, so that in case of fire the operator can leave the room without letting a cloud of smoke into the auditorium to terrify the audience.

8. It should be large enough to hold all apparatus and still allow not less than two feet (three is better) in the clear behind the machines after they have been set far enough back from the front wall so that the operator can pass between the lens and the wall, with not less than 6 feet in width for a single machine and three additional feet for each additional projector, stereopticon or spot light. The ceiling should be as high as possible—the higher the better, within reason, of course, but should in no case be less than six and one-half feet in the clear. That should be regarded as an absolute minimum, but less than seven is very bad.

9. All openings should be equipped with fire-proof shutters which will close quickly and automatically in case of fire, except the vent flue, which must be unobstructed if there is a fan, and if of the open type must have a damper weighted to remain normally open, as will be hereinafter explained. The observation port should be fitted with a movable shutter which can be raised or lowered to suit the convenience of the operator, as will be set forth further along.

10. There should be a vent flue leading as nearly as possible directly to the open air above the roof. If of the open type this flue should have an area of at least 288 square inches, regardless of the number of projectors used or the size of the room. There will be just as much smoke from a film burning in a small room as from one burning in a large room. If a fan is installed in the vent flue then it should be large enough to accommodate a 16-inch fan. There should be a separate vent flue in the rewinding room, if there be one, of the same dimensions as the one in the main room.

11. The interior walls and ceiling should be painted with a very dark or black flat paint—paint without any gloss. This is important because of the fact that the darker the operating room the better able will the operator be to see the shadows in his picture.

12. All wires should be in conduit, and the conduit system thoroughly grounded. Fuses and switches should be in metal cabinets, or in cabinets built into the wall and covered with a metal facing. Conduits should, where possible, be built in the walls, and conduits leading to the projectors should be

carried under the floor to a point immediately under the lamphouse of each projector.

13. Iron lined operating rooms should not be allowed, but if they are, then the floor should be covered with a good insulating floor covering, such as cork matting, rubber matting, or heavy linoleum.

14. The room should contain nothing except the things necessary to the work of projection.

15. There should be proper tool racks and closets for each operator's clothes and tools, a substantial work bench with a good vise, though this need not necessarily be located in the operating room.

16. The arrangements should be such that all apparatus, switches, etc., will be easy of access to the operator, both for manipulation and repair. It never pays to make things unhandy. On the contrary it does always pay to arrange them conveniently.

17. It should contain only the most up-to-date apparatus, and that apparatus should be kept in perfect condition. *It should (and this is of paramount importance—it cannot be too strongly emphasized) have observation ports of amply large proportions so that the operator may have a clear, unobstructed view of the entire screen, either when seated or standing in operating position. This may be readily accomplished by installing a special sliding port shutter, as will be hereinafter explained.*

18. The exterior of the room should be as inconspicuous as possible; that is to say, it should be decorated to harmonize with the rest of the theatre, or, if possible, to form some ornamental part in the general scheme of decoration.

19. *It should be placed in charge of a thoroughly competent, reliable staff of operators, possessed of both practical and technical knowledge of the art of projection, supplemented by a good fund of horse sense. No application for position as operator should be considered unless the applicant can show that he has had at least one year's experience, or has served one year's actual bona fide apprenticeship in an operating room.*

The foregoing constitutes what might be termed the fundamental essentials of operating room construction and equipment, but a detailed explanation is essential in addition to this.

Operating Room Door.—The door of the operating room should not be less than 2 feet wide by 6 feet in height, and it

must, of course, be of fire-proof material. The sliding door held normally closed by gravity is best. This idea is illustrated in Fig. 80.

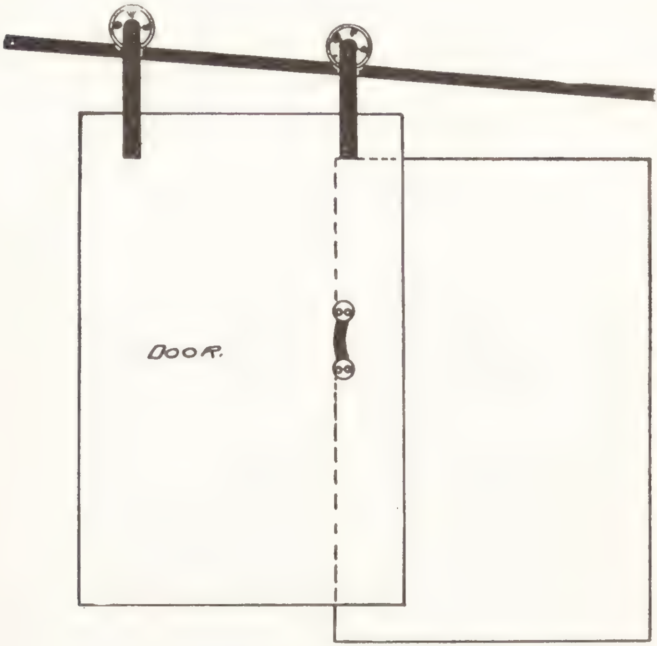


Figure 80.

Operating Room Floor.—It is of extreme importance that the operating room floor be perfectly solid, rigid and entirely free from vibration.

Figure 81.

Suppose for instance your operating room floor vibrated evenly all over just 1/64 of an inch. This means your whole picture is jumping up and down on the screen precisely that much, and on the whole this would scarcely be perceptible.

On the other hand, however, let us suppose the floor vibrated in such manner as to move the lens of the machine up and down in teetering fashion the same amount. Assuming a throw of 100 feet the movement would then be very perceptible indeed on the screen. It is illustrated in Fig. 81, in which A is the crater of the arc and B the objective lens. If you move A down 1/64 of an inch and at the same time move B up 1/64 of an inch you will readily see what will happen out at the screen surface one hundred feet away. The dotted line illustrates it.

Modern practice is to fill in with not less than six inches of rich concrete and after tamping this down well finish the top off with one inch of cement, the same as is used for sidewalks. But let me caution you that many contractors will use a cheap cement unless you specify the kind and see that it is used. The result of using this cheap cement is that it constantly wears away into dust, thus keeping everything in the operating room covered with dirt. I have seen many operating rooms made that were nothing short of an outrage in this respect. The only remedy was to paint them with oil paint. It is also well to see that the cement finish is mixed with sand in proper proportions. Remember that, strange as it may seem, not all contractors are followers of the Golden Rule, and sand is cheaper than cement. Also after the job is done the novice cannot detect the swindle at once; he may never detect it, in fact, but simply knows there is something wrong with the operating room floor.

If the floor is built of concrete and cement, and the precautions I have named are taken, it will to all intents and purposes be one solid block of stone when it has set, and you won't have any vibration at all, because a thing of that kind is too heavy to vibrate.

Ports.—There must be one observation and one lens port for each projector, one lookout and one lens port for the dissolver, if there is one, and a combined lens and observation port for the spot light, except that if the projector be a combined picture projector and dissolving stereopticon, then it must be provided with two lens ports, one small and square or round, and one narrow and high.

Locating Lens and Observation Ports.—There is a right and a wrong way and a hard and an easy way to do almost everything, including the locating of lens holes. The author has seen it done in many different ways, but the following method seems, everything considered, easiest and best.

If observation port holes are built into the wall and made of the right size, it will require extremely accurate work—more accurate than is likely to be done by the average brickmason, concrete or hollow tile man to get them exactly right. I would strongly recommend the following procedure.

Lay out your operating room wall as per Fig. 82, in which A, B, are machine lens ports, and C, D, observation ports, the

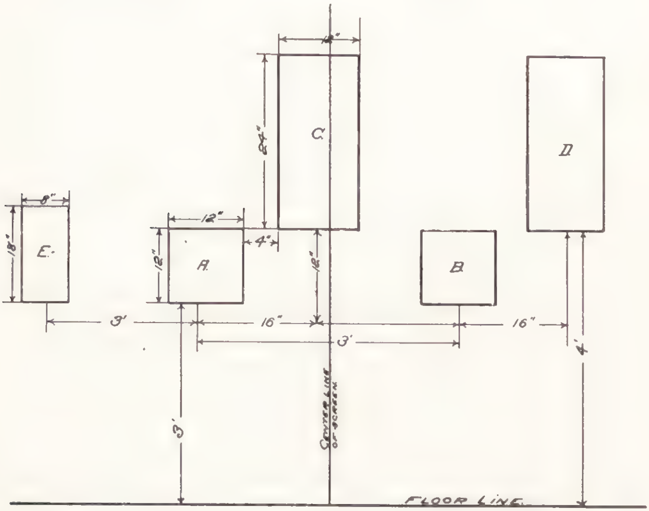


Figure 82.

NOTE: Through an oversight the stereopticon observation port was omitted. It should be 8" square, located at convenient height, its center about 5' 6" from the floor.

latter designed to be covered by a sliding port-shutter, and E the stereopticon lens port. It will be observed that ports A and B are 12 inches square, and that port E is 18 inches high by 8 inches wide, which is, of course, far in excess of actual requirement.

Taking, for example, the Simplex projector with standard pedestal; when it sets level its lens is 47½ inches from the floor, and this is approximately the height of the lens of other modern projectors. It will be observed that ports A and B are located 3 feet center to center, and that their centers are 18 inches on either side of the center line of the

screen, which must be first located on the plan. It will also be observed that the bottom of ports A, B is 3 feet from the floor, which brings their center 42 inches above the floor line, whereas the lens will be 47½ inches from the floor. In most cases, however, there is a more or less steep pitch in the projection, so that, in ordinary cases, if the projector be located with the lens 20 inches from the wall, as it should be, the light ray will strike approximately the center, or even below the center of the large port.

After the wall has been built, the floor finished, projectors in place and the light finally projected to and located on the screen, and the machines permanently bolted down, insert a piece of asbestos millboard, 3/8 or 1/2 inch thick, set flush with the *outside* edge of the wall, as per A in detail sketch, Fig. 83, strike the arc, project the light ray on this board, mark a circle around the light, cut out the circle, replace the board in the opening and cement it in as per detail sketch Fig. 83.

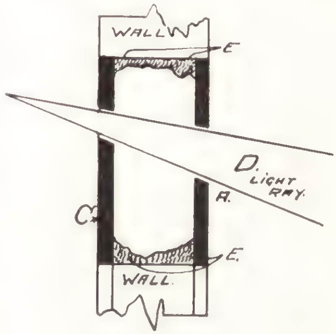


Figure 83.

Having completed this, set another board, C, Fig. 83, flush with the *inside* edge of the wall, and proceed as before. You will then have your lens port in exactly the right location and precisely the right size, and you will have it, too, with a minimum amount of trouble.

The observation ports C and D, you will observe, are 12 by 24 inches, with their bottom located 4 feet from the floor line, and their center 16 inches from the center of the lens port. These ports are designed to be covered by an asbestos millboard, or metal sliding shutters, as per Fig. 86, the detail of which, together with detail of grooves, is shown in Figs. 84 and 86.

Port E, Fig. 82, is the stereopticon lens port, and is treated the same as ports A and B, except that there will be two small light ray holes in the asbestos millboard, instead of one.

This is the easiest method of locating the lens ports, and it will be found to serve perfectly, I think, except in very rare cases where there is a perfectly level projection, in which

case ports A and B should be located 6 inches higher, or where there is an extraordinary steep pitch in the projection, in which case ports C and D must be located lower, as possibly must also ports A and B.

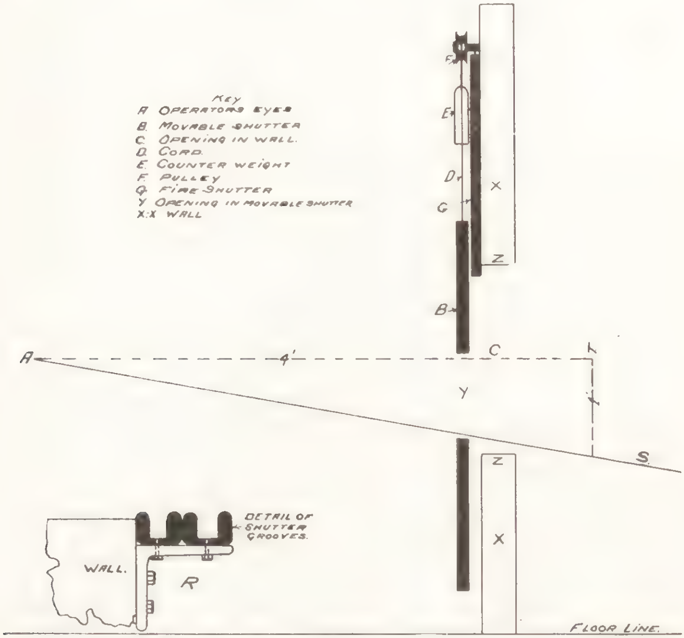


Figure 84.

In cases of very steep projection the height of the ports may be located as per Fig. 84. First locate the height of the operator's eyes when seated in operating position. I have assumed this to be 4 feet from the floor and 3 feet away from the wall, at A, Fig. 84. Now measure the exact distance from Point A to the bottom of the screen, using the elevation plan of the theatre, if there is one, also the exact vertical height from the bottom of the screen to point A, Fig. 84. Draw a rough plan, to scale, by laying off the height of the operator's eye above the bottom of the screen, and the horizontal distance to the screen. Then draw line S, Fig. 84, extending from point A to bottom of the screen.

Having done this, measure from the operating room floor line straight up to where line S bisects the line of the front operating room wall, and that will be the bottom of your observation port, though you should make it two or three inches lower than the actual measurement from the floor to the line. The lens ports may be laid out in exactly the same way.

Still another way is by calculation. This, too, is shown in Fig. 84, in which I have assumed that the bottom of the screen is 20 feet below point A, and 80 feet away. Dividing 80 by 20 we find there is a drop of one foot in each four feet of horizontal distance, so that by measuring four feet horizontally from point A we establish point T, and then measuring down vertically one foot we get the exact projection pitch, and thus know where to locate the bottom of the port.

For all ordinary cases, however, the plan first described will serve.

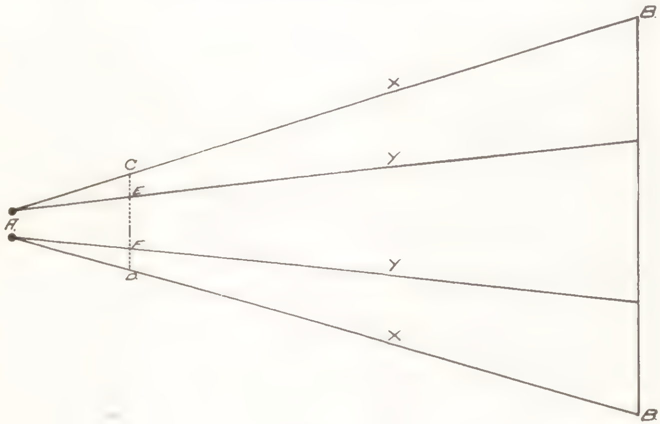


Figure 85.

THE OBSERVATION PORT

The hole in the wall itself should in no event be less than 12 inches wide. The necessity for a wide port is illustrated in Fig. 85, in which A represents the eyes of the operator located, when seated or standing in normal operating position, from 2 to 3 feet back of the operating room

wall. B-B is the screen; lines X-X represent the view the operator should have of the entire screen, and would have did the width of the port extend from C to D; lines Y-Y show the view the operator actually has of his screen if the port is narrow and only extends from E to F. In this event he is compelled to bring his eyes right up close to the opening in order to see the entire screen, and that is a bad condition, from any and every point of view.

I know of no other one thing which operates to produce poor results on the screen to as great an extent as do narrow and badly placed observation ports.

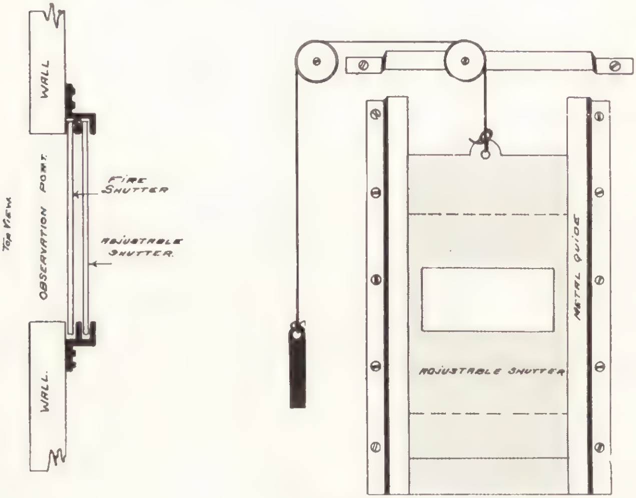


Figure 86.

With his eyes right up close to the wall, the operator must, of necessity, at least to a certain extent, neglect his projection machine and his lamp. Moreover:

No operator will stand for hours with his face glued to the wall, watching his picture continuously; and unless it is watched continuously and closely there will be shadows on the screen, or, in other words, there will be faults in the projection.

That is a proposition which is not a subject for argument. It is a statement of fact, which managers will do well to recognize and consider very seriously.

The height of the observation port is a much harder matter to determine. If the ceiling of the room itself be high enough to allow of the installation of a sliding port, such as that illustrated in Fig. 86, I would strongly recommend that the hole in the wall be 12 inches wide by 24 inches in height, as per Fig. 82, and that over this hole there be installed a movable shutter made of ⅜ or ½ inch asbestos millboard, or of metal, if preferred, although asbestos board is better, behind which should be installed the regular asbestos or metal fire shutter, both sliding in grooves, as shown in Figs. 84 and 86, the movable shutter to be hung on a counterweight.

In Fig. 86 the shaded portion represents the movable shutter, also shown at B, Fig. 84. It should be at least 14 inches wide, with an opening not less than 6 by 12 inches. I believe the illustrations make the matter perfectly clear, but in order to use this kind of shutter it is necessary there should be head room above the opening in the wall sufficient to allow the shutter to be raised so that upper edge of opening Y, Fig. 84, will come to the top edge of the hole in the wall at Point Z, Fig. 84, and the lower edge of opening Y go down to the lower edge of the hole in the wall. It is not necessary that this shutter raise or drop far enough to entirely close the opening in the wall, that being taken care of by fire shutter G, Fig. 84.

In Fig. 84 the grooves in which the shutters slide are omitted in the main drawing in order to show other things. They may be made from small angle and channel iron, readily obtained from dealers in structural iron. Any hardware dealer can obtain them for you. What is perhaps the most convenient method is to secure about 12 feet of 1¼-inch angle iron and the same amount of ½-inch channel iron for each 24-inch observation port, and, after cutting to proper length, bolt the channels to one side of the angle as at R, Fig. 84. This leaves the other side of the angle to be fastened to the wall. If properly put together this makes a most excellent shutter groove. The one shown at R, Figs. 84 and 86, is designed to carry the movable port shutter and the fire shutter behind it. For single grooves one-inch angle iron is ample.

The whole idea of the movable shutter is to allow port Y, Fig. 84, to be placed in any desired position, to suit a tall or short operator; also to accommodate a man when either sitting down or standing up. Many authorities insist on the

observation port being not more than 4 or 6 by 12 inches. Now, a fixed port 4 or 6 inches high would be extemely awkward, since if placed to fit a five-foot man would be mighty bad for a six-footer, or vice versa, so they try to get around that difficulty by standing the thing on end, with result as shown by lines Y-Y, Fig. 85. The movable shutter enables the theatre owner to comply with the demands of the authorities in this respect, and still have a port which is excellent in every way. It is a shutter which appeals to common sense, and no official can possibly advance any valid objection to it.

The careful planning and locating of the observation ports, as hereinbefore set forth, will require a little thought and consume a little time, but if you locate them in such manner that the operator will be continuously inconvenienced you have no right to expect that you will have uniformly high class results on your screen, and let me tell you you probably won't have them either.

A little time spent in careful, intelligent study of this matter of planning and locating the observation ports will place the operator in position to give you much better service, and he will do it, too. Therefore it naturally follows that the time thus expended is a most excellent investment.

The stereopticon observation port is not of so much importance, and a six or eight inch square or round hole will do, since, ordinarily, one uses the stereo but a few minutes at a time, and can put up with some inconvenience if necessary. The stereo lens port can be located the same as per directions for the projection machine lens holes, but in the case of the stereopticon the hole in the wall need not be more than 8 inches wide, but it should be 18 inches high, the same to be filled in with asbestos board afterward, as directed for the other lens ports.

The spot light port, if one there be, should be located with its center 5 to 5½ feet above the top of the floor, and should be 16 to 18 inches in diameter, square or round, as preferred.

Wall Fire Shutters.—Every observation port and vent opening should be provided with a fire shutter made of 3/8 inch asbestos millboard, although some authorities are satisfied with 16-gauge sheet metal. Metal is, however, not as desirable, I think, as asbestos board for this purpose.

In Fig. 87 is shown the proper method of bracing the wall shutters to keep them perfectly flat. The braces are of

1 by ¼-inch iron secured to the shutter either by short, heavy screws or stove bolts.

The proper installation of these shutters together with an adequate vent flue and thoroughly fire-proof walls offers not only absolute protection from fire damage to anything outside the operating room, but also against the probability of alarm on the part of the audience. This latter will not be accomplished, however, unless the fire shutters be so made that they will close the instant a fire starts. *This last is of supreme importance.* It is seldom indeed the fire itself which causes loss of life or injury to an audience. It is the panic which almost invariably follows an alarm of fire where an audience is gathered. Ninety-nine times out of every hundred there are abundant time and opportunity for every one in the theatre to escape with perfect safety, provided the audience acts rationally, but the fact is an audience seldom or never does remain rational or sensible when an alarm of fire is given, *particularly if either fire or smoke be visible.* Given a glimpse of fire or smoke, as a general proposition you may depend upon an audience to go stark, raving mad, pile up in a heap and kill each other through trampling or suffocation.

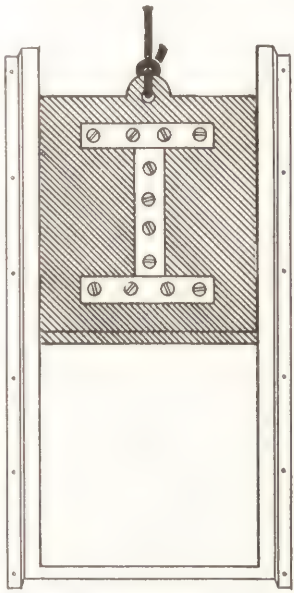


Figure 87.

I desire to strongly impress upon architects and moving picture managers and owners that it is entirely practical and feasible to prevent any glimpse of fire or smoke by the audience when a film catches fire, but in order to accomplish this fire shutters must be installed which will automatically close every opening in the operating room wall the INSTANT *the fire starts.*

Depending upon the operator to drop the shutters is by no means a safe proposition. The operator is but human, and when the film catches fire he is very likely to become more

or less excited, and it is a cold fact that you never can tell what an excited man will do, or what he won't do. Therefore I emphasize the fact that *it is a dangerous mistake to allow the installation of fire shutters in any other way than approximately as hereinafter described.*

Fig. 88 is a diagrammatic representation of the front operating room wall. The door is not located in the front wall because it should be there, but merely for convenience in showing the proper arrangement of the master-cord, which should terminate in ring A, held by an ordinary heavy spike,

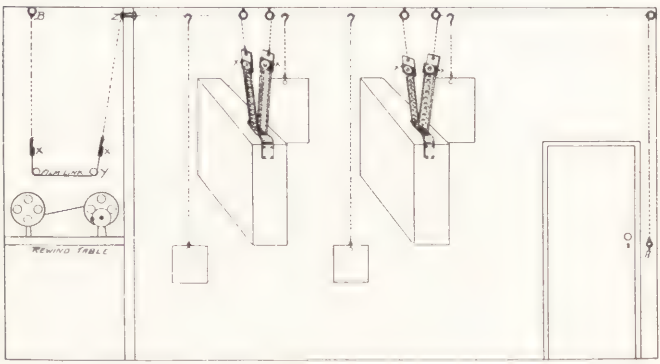


Figure 88.

nail, or bolt, driven into the wall beside the latch of the door.

This whole proposition hinges on the kind and location of the fuse links. The master-cord is cut into sections, and these sections are joined together with fuse links, located over each machine magazine, the film box, and over the rewind table in the rewind room. These fuse links may be of 160 *degrees fuse metal, but preferably should be of film, as shown in Fig.* 88. *in which the fuse clamps are drawn out of all proportion as to size in order to show the thing more clearly.*

In Fig. 88 the dotted line represents the master-cord, which is stretched from point A to point B, as shown, though the cord may be carried in any other convenient way, provided only that the links be located with relation to the machine magazines, film box, and rewind substantially as shown. The master-cord may be of heavy cord *of such nature*

that it will not stretch, or it may be of No. 22 copper wire, provided some unthinking official does not object. The film links over machine magazines should not be more than 12 or less than 6 inches long, and should not be more than 3 inches above the top of the magazine. The same is true of the link over the film box. The one in the rewind room may be of convenient length, but *there must be distance enough between clamp Y and insulator Z to allow the master-cord to slack sufficiently to let all the shutters go clear down.* If this distance be too small there is danger that clamp Y will strike hole Z before the shutters have entirely dropped.

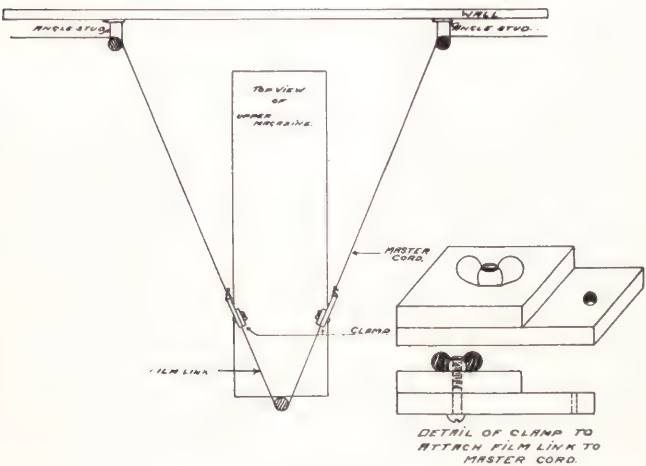


Figure 89.

The detail of the method of clamping the film to the cord is shown in Fig. 89, as is also the details of one method of attaching the fuse link over the upper machine magazines. *Rings should not be used in place of angle studs X,* because in that case when the film lets go the clamp might catch in the ring and prevent the shutters from dropping, whereas with angle studs when the master-cord slacks it instantly drops down off the studs.

If metal fuse links are used they should be located approximately the same as the film links shown. Angle studs X may be made by obtaining heavy screw hooks, such as

housewives use to screw into the ceiling to hold the family bird cage, etcetera, but the hook should be straightened out until it stands at approximately right angles to the screw, and the end should point downward, not up, when it is finally in position. The upright bolt attached to the magazine around which passes the film link, or the master-cord if a metal link is used, should be made of $\frac{3}{8}$ or $\frac{1}{2}$ inch iron, flattened at one end and attached to the magazine by stove bolts, as shown.

Having arranged our shutter cord the rest is simple. The individual shutters are raised and attached to the master-cord by their own individual cords, which terminate in a hook designed to attach to the master-cord. The master-cord remains permanently in place. It is never touched except possibly to tighten it if it gets slack. The shutters are raised one at a time in the morning and lowered one at a time at night.

I believe that with what has been said and the aid of Figs. 88 and 89, you will be able to understand this matter thoroughly.

The whole proposition is to place the fuse links where a fire, either at the film box, the rewind table or at either machine, will INSTANTLY strike one of them, thus severing the master-cord and dropping all the shutters *before there is any smoke or blaze visible to the audience.* Incidentally, however, it is exceedingly important that the bottom stop upon which the shutters fall be heavily padded with shredded asbestos, since if the shutters fall on anything hard they will make an awful clatter and direct the attention of the audience straight to the operating room—the very last thing to be desired.

It will be observed that by this system the operator can also drop the shutters, since ring I is placed on a headless spike right beside the latch of the operating room door. If the vent flue be of the open type, then shutter D should be weighted so that it will remain normally open, and it must only be allowed to be closed by a cord attached to the master-cord by means of a hook, the result being that when the master-cord is slacked and the shutters closed the damper automatically swings open.

An operating room thus equipped is, I firmly believe, as safe as it is possible to make it.

There is no earthly sense in installing metal fuse links in the shutter cords, and locating these links at or near the ceiling,

as is done in nine cases out of ten. Should a fire occur with the fuse links thus located, by the time they become sufficiently heated to melt there would probably be very little use in closing the shutters at all, because the audience would most likely have seen the smoke and blaze and be piled up in a heap, climbing over each other in their mad endeavor to escape a fancied danger.

There are those who may argue that the shutters should be dropped gently, and that this can only be done by the operator; that if dropped suddenly as by a fuse melting, there will be a slam which is likely to attract the attention of the audience to the operating room, since even with the shutters falling on pads there is bound to be some noise pro-

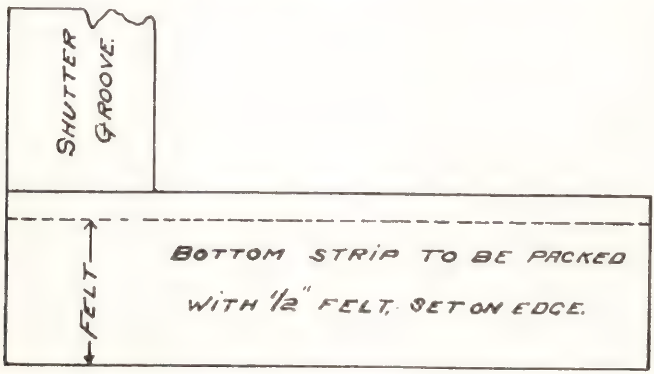


Figure 90.

duced when from two to eight shutters are released and allowed to drop unrestrained.

This is a matter concerning which there may well be honest difference of opinion, but the writer strongly favors very careful padding of shutters, as per Fig. 90, and carefully placed fuses, because there is always the liability of an excited man forgetting to drop the shutters; also if the operator is to be depended on why place any fuse at all? Better make it one thing or the other, and I believe fuses are the thing.

The Vent Flue.—The vent flue of the operating room is an exceedingly important matter, since it not only provides ventilation, but must be depended upon to carry the fumes and

smoke from burning film, should a fire occur. The vent flue should, where possible, pass directly from the operating room ceiling through the roof to the open air, with its top not less than 3 feet above the roof and protected by a suitable hood to prevent rain from beating in. For a long time the author favored the open vent flue, as against the installation of a vent-flue fan. However, further and careful study of the subject has changed his views. This change was largely brought about through realization of the fact that under certain conditions it is quite possible the draft through an open vent would be down instead of up; this is especially true in certain locations, or when the wind is in certain directions, as any housewife who has experience of a smoky chimney can testify. This being the fact, I am convinced that a fan in the vent flue is better than an open pipe. *If, however, the vent pipe is of the open type it should have an area of not less than 288 square inches, regardless of the size of the room. A burning film will make just as much smoke and gas in a small room as it will in a large one.* It should be provided with a damper, weighted to remain normally open, and only allowed to be held closed by a cord attached to the master-cord of the fire shutters in such manner that when the fire shutters are closed the vent flue damper automatically will swing open.

If a fan is installed in the vent pipe it should be not less than 16 inches in diameter and it would be exceedingly good practice to install two vent pipes and two fans instead of one, so that in case one of the fans gets out of order there will still be the second one to fall back on. This may seem like a rather expensive precaution, but somehow or other it seems to be a fact that when a thing happens it usually happens just as the wrong time, which, applied to the single vent flue, would mean that a fire would most likely occur when the fan was broken down.

It is essential that the vent flue, if made of metal, be thoroughly and completely insulated from any inflammable substance throughout its entire length, since it is likely to get very hot if there is a serious fire. The safest plan is to make a double pipe, with an air space not less than 3 inches between the inner and outer walls.

Operating Room Ventilation.—The ventilation system of the operating room is a matter of much importance. It must be remembered that the operating room is often located immediately under the roof of the building and in any event

would be extremely hot in summer time. Add to this the heat generated by a powerful arc lamp, and perhaps one or two rheostats, and you have a condition which *makes good ventilation absolutely imperative. It must also be remembered, in this connection, that air taken in from the auditorium will be that which has arisen from the audience, and will therefore not only be the very warmest in the house, but also vitiated and rendered unfit for use by a human being.* Moreover, if it is taken in entirely through the lens and observation ports an unpleasant draft is likely to be created, which blows directly in the operator's face. This latter may be stopped by installing glass in the ports (see "Glass in Ports" further on), but in that event other means of letting in air must be provided, and should be provided, whether glass is used or not. This is best done by making inlet openings near the bottom of the room, the same connected with the outer air at any convenient point, thus supplying the room with fresh air instead of hot, foul air from the auditorium. But these latter openings should be provided with fire shutters which will close automatically in case of fire, in order to stop the draft. The heat of the room may also be largely reduced by connecting the top of the lamphouse to the operating room vent flue by means of a 3 or 4 inch metal pipe, having riveted joints. This pipe must be provided with a swing joint if the lamphouse must be shoved over to accommodate a stereopticon lens. This arrangement also operates to reduce condenser breakage by providing ample ventilation in the lamphouse. It is not costly to install, and will last indefinitely. Things of this kind add greatly to the comfort of the operator, and hence put him in better position to do his best work. The Massachusetts law contains the following provision concerning the ventilation of operating rooms, which is worthy of emulation:

Operating rooms to be provided with an inlet in each of the four sides, said inlets to be 15 inches long and 3 inches high, the lower side of the same not to be more than 2½ inches above floor level. Said inlets to be covered on the inside by a wire net of not greater than ¼-inch mesh; netting to be firmly secured to the asbestos board by means of iron strips and screws. In addition to the above there shall be an inlet, in the middle of the bottom of the operating room, if possible; otherwise in the side or rear of the operating room, not over 2½ inches from the floor. Said opening to be not less than 160 square inches area for a No. 1 operating room, 200 square inches area for a No. 2 operating room, and 280 square inches area for a No. 3 operating room; connected with the outside air through a galvanized iron pipe with a pitch from the operating room downward to the outside wall of the building. The opening to be covered with a hood, so arranged

as to keep out the storm, and the entrance to the operating room to be covered with a heavy grating over ½-inch wire mesh, if in wall; and arranged with damper hinged at the bottom, and rod or chain to hold said damper in any position. Mesh and gratings to be securely fastened in place, those in the walls to be bolted on as specified for the smaller inlets.

Note: No. 1, No. 2 and No. 3 refer to the size of rooms.

The same law contains a provision for a vent pipe not less than 12 inches in diameter from the ceiling of the operating room to the open air outside the building, or to a special incombustible vent flue. In a two-machine operating room this pipe must be not less than 16 inches in diameter and in a three-machine operating room it must be not less than 18 inches in diameter.

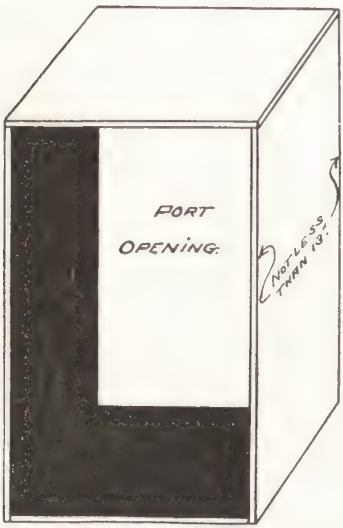


Figure 91.

Glass in the Ports.—Many operators are now using glass in both lens and observation ports, and this is a practice I can thoroughly recommend, provided the glass for the lens port be carefully selected and quite thin. I think an old photographic plate would probably be ideal for the lens port, first, of course, cleaning the photographic emulsion off by washing with a strong solution of hot water and washing soda. I would strongly recommend that the observation port be surrounded by a shadow box, 12 to 18 inches in depth, painted dead black on the inside. By shadow box I mean a casing such as you would have if you knocked the bottom out of a box and nailed what remained over the port. Where a box of this kind is not used there is more or less reflection from the surface of the glass, and, while operators say that after a few days' use they do not notice this, and that it does not interfere with their view of the screen, still I take the liberty of doubting the correctness of this statement. I

believe they would be better able to see faint shadows on the screen with a shadow box surrounding the port, as per Fig. 91.

Operating Room Equipment.—Remembering that box office receipts of a moving picture theatre depend to a very great extent upon excellence of the results upon its screen, the wise manager will bend every energy toward the attainment of artistic projection, and will use every reasonable endeavor to enable his operator to produce high class, brilliant, flickerless pictures, projected at proper speed to bring out and emphasize every good point and minimize any weak ones there may be. It goes without saying that there is small probability of continuous high class results coming from an ill-placed, small, poorly ventilated operating room, with inferior or worn-out equipment in charge of an operator of mediocre ability.

It also follows that the best results will be had from a rightly located, commodious, well ventilated operating room, equipped with up-to-date machinery and placed in charge of a thoroughly competent operator, who will keep the equipment in the best possible condition, the term "competency" including industry and careful attention to detail, as well as knowledge.

The mere possession of knowledge counts for little or nothing if its possessor is too lazy or shiftless to apply it in practice.

In planning the operating room the architect should include two small clothes closets *with substantial locks thereon,* so the operator may have a place to keep his private belongings; also it is well to have two tool cabinets which may be locked up securely—one for each operator. An operator should have a full equipment of tools, but it is rather discouraging to provide a costly kit of tools and then be compelled to leave them at the mercy of any one, from the janitor to the chance visitor, to say nothing of the other operator, who perhaps has none of his own, and, moreover, may not be inclined to take the best care of those belonging to others. There should be drawers, or a closet in which to keep supplies, such as carbons, extra condensing lenses, etc., though, of course a shelf will serve, and if the walls be built of cement it is a comparatively simple matter to provide cement shelves when the room is built. The supply closet may be built outside of the operating room if desired. There should also be plenty of hooks on which to hang wire, etc. It is an exceedingly unprofitable thing to spend time hunting for a piece of wire or a tool, or some needed repair part, when

something goes wrong. All these should not only be kept in stock but *be kept in place, where the operator can find them instantly when they are needed.* For instance: fuses should be kept near the fuse cabinet; when a fuse blows it is no time to be rummaging around through a miscellaneous lot of supplies to get a new one. If a wire burns in two, possibly stopping the show, it is no pleasant thing to have to look through a pile of miscellaneous tangled odds and ends of wire to find what you need. The point I am making is: *Have a place for everything and everything in its place.* This is not likely to be done, however, unless proper shelves, hooks and closets be provided.

If an operator does not keep things in order, being provided with proper places in which to keep them, then he is not the right sort of man to have in charge of an operating room.

There should by all means be a wash basin, with running water, and a toilet either in or convenient to the operating room; both of these are quite essential, particularly where only one operator is employed. Often something will go wrong with the machine and the operator will get his hands covered with oil and dirt in making repairs. If there is no means of washing them, the next time he handles a piece of film there is likely to be considerable damage done. He is also very apt to soil everything he touches. From any and every point of view a wash basin ought to be installed in or near the operating room, and *a toilet should be required by law,* since in many cases the operator is literally chained right there in the operating room for hours at a stretch.

An one end of the operating room there may be a rewinding room, the two separated by a fire-proof wall and door, the shutter master-cord passing through this wall and down over the rewinding table, with a fusible link, as already set forth. If there is a motor or generator set, or a mercury arc rectifier, there should be a separate room provided for them at one end of the operating room. These machines should not be placed in the room where the film is rewound, and a mercury arc rectifier should never be placed in the operating room itself, because it makes the room too light, and it is thus made difficult for the operator to discern faint shadows on the screen.

Supplies for the Operating Room.—I cannot imagine a more foolish and utterly mistaken policy on the part of a manager than to be niggardly in the matter of projection room supplies. On the other hand I by no manner of means approve of the operator wasting supplies or being extravagant with them.

I take the position that an operator who cannot be trusted to be careful and economical with supplies when he has plenty is not a fit man to be in charge of an operating room.

However, in this connection it must be remembered that

A good, competent operator, who understands his business and is allowed to do things as they should be done, does not wait until a part breaks down entirely, thus perhaps stopping the show until repairs are made; he renews worn parts before the break comes.

It is false economy, from any point of view, to try to get the last particle of wear out of operating room equipment. Take, for instance, asbestos wire lamp leads. Altogether too many operators use their lamp leads, particularly that portion inside the lamphouse, too long. Inside the lamphouse the wires are subjected to increasing heat from the arc as they approach nearer to it, and as the temperature of metal rises its resistance also rises. Copper oxidizes under the action of heat, and where a wire is worked close to its capacity electrically, and you add a high temperature of heat from an outside source, the effect is to raise the resistance of the wire, thus lowering its carrying capacity and setting up still more heat and rapid oxidization and deterioration. In a very short time the strands turn brown, then dark brown, and presently if you bend the wire near the lamp binding post, you will find it has no "spring"; it is like a piece of string. *Under this condition its resistance is very high and it is consuming wattage which in a few hours' time will more than equal the cost of the wire.* If you strip the asbestos back you will probably find its strands have turned brown for a considerable distance.

I would recommend that where No. 6 asbestos stranded lamp leads are used they be cut off and that a good, heavy wire connector, D, Fig. 30, be attached and then connection made from that to the lamp with a short piece of the same wire. Then where, say, 40 amperes are used, once every week remove this short piece of wire, throw it away and substitute a new piece. This will cost you a little more than twenty cents, but *it will save that much or more in current,* besides giving a better light. Where less than 40 amperes are used the wire can be continued in use for a somewhat longer time. When the amperage is very high, larger wire, or No. 6 doubled, should be used inside the lamphouse.

There is always tendency to use the intermittent sprocket of the projection machine too long. Intermittent sprockets

of modern projectors are very carefully made and hardened, but, notwithstanding this fact, in the course of time the constant wear of the film will cut a notch in the side of the sprocket teeth and in time wear them into a hook shape, which has tendency to produce unsteadiness in the picture, as well as do serious injury to the film itself. Therefore, this being the fact, it would be true economy to replace the intermittent sprocket before the teeth show any appreciable wear when subjected to examination, using a condenser lens as a magnifying glass.

I mention these two examples merely as typical, and place them in evidence as showing that it does not pay to be too economical in the matter of operating room supplies; also as proof that lack of knowledge often causes a manager to practice what is in effect false economy, or, in other words, practice economy which is, as a matter of fact, exactly the opposite. It never pays to compel the operator to use worn parts, since worn parts always tend to injure results on the screen.

Managers would do exceedingly well to secure an operator in whose judgment they have confidence, and, having done so, allow him reasonably free hand in the matter of supplies.

It is an absolute fact that failure to grasp this simple idea, and apply it in practice, is causing the moving picture industry many, many thousands of dollars every year through loss of business. Tens of thousands of people would be more regular patrons of moving picture theatres if the pictures in those houses were placed on the screen in the best possible manner, but placing the picture on the screen in the best possible manner is utterly impossible to the operator who is not supplied with proper equipment or with needed repair parts.

In the operating room should be an ample supply of carbons, wire of the various kinds used, plenty of fuses of the different sizes and kinds used, slide cover glasses (clean, not dirty), stereopticon mats and gummed binder strips, extra parts for the intermittent movement, and, if it be a Power, Motiograph or Simplex machine, then an entire intermittent movement, including the framing carriage, already assembled and ready to slide into place in the machine; extra machine bushings for intermittent and cam shaft bearings, extra condensers, and, in fact, everything likely to be needed.

In the room should be some sort of a water-tight, metal receptacle of such form that it will not be easily upset, this to be kept half full of water to receive hot carbon butts. If the operating floor is covered with iron (bad practice, but

still followed in some localities) it should be covered with insulating material, such as cork matting, rubber matting or linoleum, or at least there should be an insulating mat of ample size on the operating side of both machines and the stereopticon, otherwise the operator is most likely to be subjected to unpleasant shocks, though this does not hold true if the lamphouse be thoroughly and effectively grounded to the floor.

Operator's Chair.—Some managers insist upon the operator standing up, and will not allow a chair in the room. With all due respect to them, that is pure, unadulterated nonsense. Some men prefer to stand up, but to other men standing several hours continuously on their feet is a tremendous hardship. The writer, for instance, could not and would not do it. At the end of two hours he would be too badly exhausted to do good work. Anyhow, there is no earthly reason why the operator should not be seated comfortably at his machine. If the observation port be properly made, so that he can view his picture from that position, there is absolutely no reason whatever to suppose he won't do just as good work seated as when standing up.

*As a matter of fact the operator is very likely to do better work when seated than when standing, because **when** standing there is always the temptation to move around, **whereas** if seated at the machine he is likely to remain right there in front of the observation port where he ought to be, and where he must be to deliver the best results. It is therefore good policy not only to allow the operator to be seated at the machine, but to provide a comfortable chair, or at least a stool of proper height.*

Ammeter and Voltmeter in the Operating Room.—It is, in the judgment of the author, an exceedingly good investment to locate an ammeter or voltmeter, particularly the former, in such position that it will be constantly in front of the operator when he is in operating position at the machine, the same to be connected to the operating room feeders, so as to indicate all current used in the room..

There is a certain point at which the projection arc will produce maximum illumination with a minimum current consumption. *Just a little movement of the carbons away from this position will jump the current consumption by anywhere from 5 to 20 per cent., without in any way increasing the light brilliancy*—in fact it is likely to decrease it. With an am-

meter placed directly in front of the operator he is able to, and, if a careful man, will maintain his arc at the point of maximum brilliancy with minimum current consumption. I believe that, in the average theatre, an operating room ammeter, *if properly located,* will pay for itself in a very short time. A good ammeter may be had at from twelve to fifteen dollars.

The method of connecting an ammeter or voltmeter is set forth in Fig. 92.

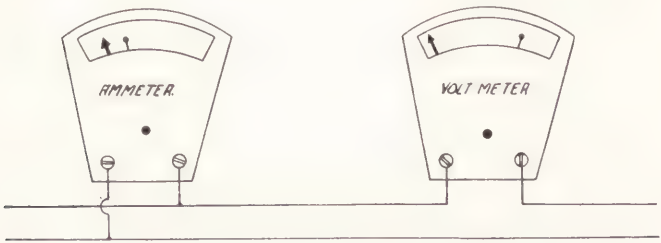


Figure 92.

Anchoring the Machine.—It is absolutely essential to steadiness of the picture on the screen that the machine itself be rigid, and without the least vibration. Most modern projectors have tables or pedestals sufficiently solid to require no additional anchoring, provided the floor itself be without vibration. However, there are still a number of old style tables in use, and, for the benefit of the users thereof, I illustrate an excellent table anchor in Fig. 93.

In Fig. 93, A is a piece of 1¼-inch pipe, at the top of which is a flange with a right-hand thread and at the bottom a flange with a left-hand thread. Pipe A is cut just long enough barely to clear the floor and ceiling when the flanges are not on.. Now screw the flange on and with a Stillson wrench turn the pipe counter clockwise, which will have the effect of forcing the top flange against the ceiling and the bottom flange against the floor, thus firmly anchoring pipe A, to which the machine table is then attached by means of part B. The front of the table may then be anchored to the front wall as shown. Legs of tables of the type shown in Fig. 93 should be set in iron sockets, or, in their absence, be placed in an indentation made in the floor.

These tables are, however, out of date, and are rapidly being discarded.

Tools.—The operator should, as has been remarked, be in possession of a kit of tools enabling him to do ordinary repair jobs. Such a kit of tools cost several dollars, but it is a good investment. The manager is likely to have more respect for the operator who owns a good tool kit than for the one who shows up with a ten-cent screw-driver in one

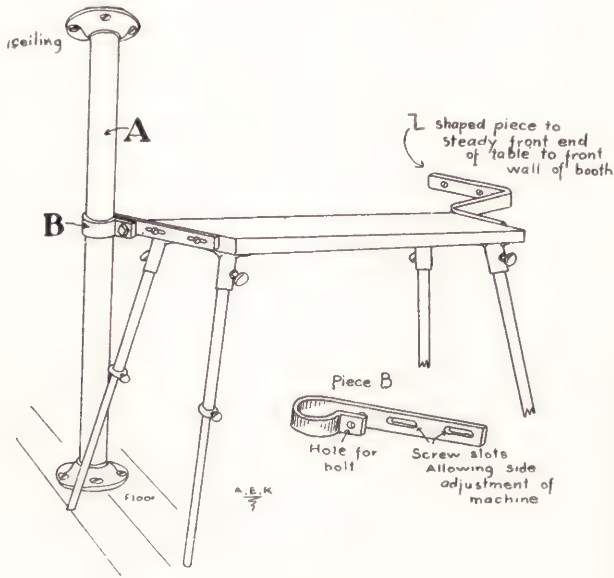


Figure 93.

pocket and a pair of broken pliers in another. In the second edition of the Handbook I gave a list of tools, to which I see no reason for either subtracting or adding, except in the item of a small hand-bellows, which is a very convenient tool with which to blow dust and dirt from around switches, and from around the pole-pieces, armature and places where a brush cannot be used on a motor or generator. This is a thing, however, which does not really belong to the operator's kit, but should be supplied by the manager, and should have a place in every operating room. It is a necessity where a

motor generator set is used. The following is the list of tools:

One pair "button" pliers 8 or 10 inch; one pair 8 or 10 inch lineman's side cutting pliers (I leave the matter of size open, as some prefer one and some the other); one pair 8 or 10 inch gas pliers; one large and one medium screw-driver; one screw-driver with good length of carefully tempered blade for small machine screws, to be heavily magnetized so as to hold small screws; one pair of pliers for notching film, see Fig. 76; one small riveting hammer; one claw hammer; one small cold chisel; one medium-sized punch; one very small punch for star and cam pins; one small pair tinner's snips; pair blunt-nose film shears (such as clerks use); one small gasoline torch for soldering wire joints; one hack-saw. With this kit you will be able to do almost any ordinary job, but you will have use for them all. In addition to the above the house manager should furnish one 8 and one 10 inch flat file, one ⅝ round file, one 8 inch "rat tail" file, a small bench vise with anvil and some soldering flux and solder wire.

In this list there is nothing which will not be found of use, and many operators will desire and acquire a more elaborate kit.

Tools in Order.—It is of the utmost importance that the operator's tools, be they many or few, be kept in order, neatly arranged on the wall, the screw-drivers and pliers within handy reach from operating position. One of the most reprehensible habits possible is that of dropping tools when one has finished using them and letting them lie until needed again.

It would be hard to estimate how many thousands of times moving picture theatre audiences have sat in the dark, waiting patiently while an operator searched around looking for the pliers, screw-driver, or other tool needed to make a repair, which he had thrown down wherever he happened to use it last. Often I have gone into operating rooms and found the operator's tools lying on the floor in a jumbled pile underneath the machine. This kind of thing is not only exceedingly unworkmanlike but decidedly sloppy. The man who does things that way is never likely to make any large success, either of operating or anything else.

My advice to the operator is have a good kit of tools and keep them neatly arranged and in perfect order.

My advice to the manager is to discharge the operator who is satisfied to own a pair of pliers and a screw-driver, or who, having other tools, does not keep them in order. If he is unworkmanlike in so important an item, it is likely he will be unworkmanlike in other things which will reflect directly on the screen in the shape of faulty projection.

Announcement Slides.—It is frequently necessary to make announcements to the audience. There are a great many different ways in which very good appearing slides can be hastily prepared. There are inks on the market, in several colors, with which one may write, using an ordinary pen, on clean, plain glass, just the same as he could write on paper. There are also a number of slide coatings for sale on which writing may be done with a sharp pointed instrument. These slide coatings are particularly to be desired for any slide which must be made on the spur of the moment, by reason of the fact that a number of them can be got ready and laid up on a shelf in a pile where they will keep indefinitely. If anything happens and you wish to say something to the audience, the operator can write on these slides with anything having a sharp point. For instance, suppose something occurs that will cause a delay of two minutes. Within five seconds the operator can write on one of these slides "Unavoidable Delay of Two Minutes," stick it in the stereopticon and project it to the screen. The audience will then be satisfied to wait for that length of time. I only suggest this as one possible way in which slides of this kind may be utilized. They should be kept in the operating room ready for instant use. Please understand in this I am not referring to program slides which the manager himself will wish to prepare, but merely those designed to be used for emergencies.

WIRING THE OPERATING ROOM

The wiring of the operating room is a matter which should be carefully planned before the construction of the room is begun, particularly if the walls are to be of concrete or brick.

The operating room feeders must be large enough to carry the entire load of the operating room. That is to say, if there are, for instance, two projection arc lamps, a dissolving stereo, a spot light and four incandescent lamps, then the operating room feed wires must be large enough to carry

the combined amperage of all these lamps when they are all burning. True, they probably never *will* be burning all at one time, but that does not alter the fact that the wires must be able to supply them all without overload.

Note.—When A. C. circuits are run in conduit *always place both wires of the circuit in the same conduit.* If they be run in separate conduits a highly objectionable inductive effect will be set up in the conduit.

In order to figure the necessary amperage capacity, proceed as follows: First estimate the combined amperage. Suppose there are two projectors and you propose to use 40 amperes from a 110 volt line through resistance. This would call for $40 + 40 = 80$ amperes at the two projector arcs. Suppose there is a dissolving stereo which requires 15 amperes per light, or a total of 30 amperes, a spot light taking 15 amperes and incandescent taking 5 amperes; thus $80 + 30 + 15 + 5 = 130$ amperes. Turning to Table 1, Page 42, we find that if the feeders be two wire, it will require 00 R. C. wire to carry that amount of current.

If, however, the feeders are three wire, then, since when the lamps were all burning the arc would burn in series on 220 instead of 110 (See three-wire system, Page 56), the amperage requirement would be cut in half and it would only be necessary to have No. 5 feeders.

Again, if all the lamps are to be operated from a motor generator set, rotary converter, mercury arc rectifier, or on current taken through an economizer (transformer), then the operating room feeders need only be large enough to supply the *primary* capacity of these devices, or the combined amperage of the arcs reduced from secondary to primary, provided this apparatus be in the operating room.

The operating room feeders should be brought in at the most convenient point, through conduits, and carried to a metal switchboard cabinet. As has been already set forth under title "Operating Room," the circuit conduits should be laid before the room is built, and be built into the wall, floor and ceiling. There is no sense in having the operator stumbling over a conduit laid on the floor; also, a conduit laid on wall and ceiling looks unworkmanlike. It looks like a "half baked" job. Do the thing right and embed the conduit in the wall when building the room, carefully planning the outlets.

The main operating room switchboard cabinet should contain (a) main feeder switch A, and fuses B, Fig. 94,

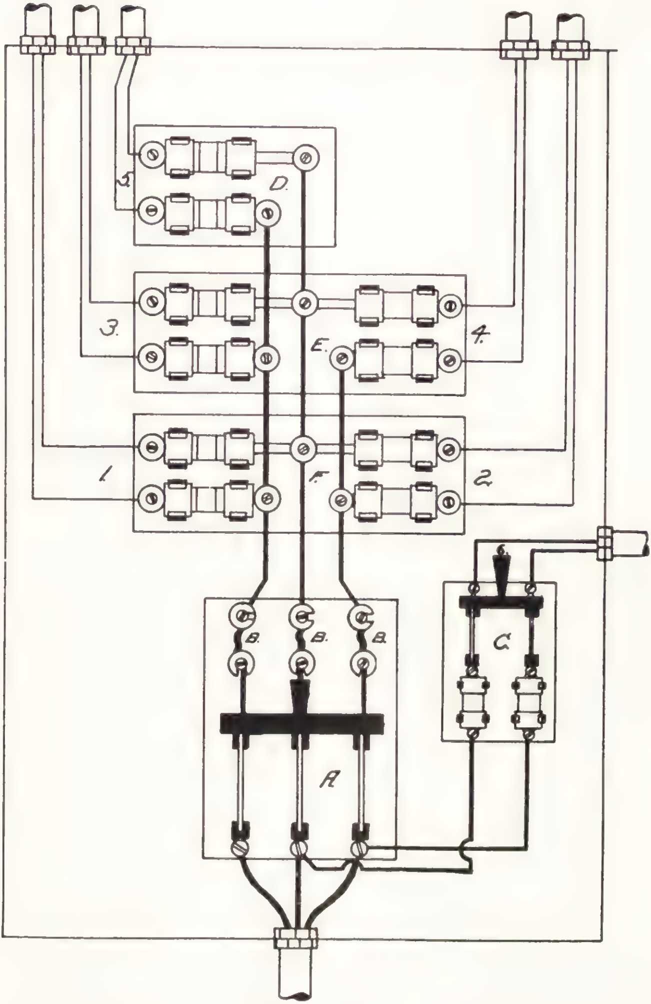


Figure 94.

carrying the entire operating room load; (b) a small switch and fuses, C, Fig. 94, carrying the operating room incandescent circuits; (c) cutout blocks D, E, F (as many as needed), carrying fuses for the various circuits, and, if desired, switches also. In the drawing, Fig. 94, we will assume circuits 1 and 2 to supply the projection machine arcs, circuit 3 and 4 the dissolving stereo, circuit 5 the spot light, and circuit 6 the incandescents.

The switchboard plan shown in Fig. 94 is merely illustrative. The board may be built up to accommodate as many or as few circuits as may be necessary. The cutout blocks shown may be porcelain base cutouts with switches, similar to those illustrated in Fig. 18, Page 72; they may be porcelain base cutout blocks without a switch, as shown, or they may be slate base switches with fuse receptacles.

Where the three-wire system is used to feed the operating room and connection is made to the neutral, the projection arcs should be connected on opposite sides. It is, of course, impossible to balance the operating room load on a three-wire system because ordinarily only one projection arc will be burning at a time, but suppose you connect both lamps of your dissolver to one side, then when the dissolver is in use, instead of the load being balanced there is approximately 30 amperes on one side and nothing on the other, which is bad. Then, too, if both projection lamps are connected to one side, when the arc of the idle machine is struck to heat the carbons, before switching over to a new reel, for a short time the entire load of both projectors is on one side, meaning that anywhere from 60, 80, 90 or even 100 amperes of current would be on one side, and this much of an unbalanced effect would be felt by a good sized power plant. To sum this matter up:

Where a three-wire system is used to feed the operating room, connect projection arcs to opposite sides and connect dissolver lamps to opposite sides, except where mercury arc rectifiers, motor generators or economizers are used, in which case it is much better to leave the neutral idle and connect only to the outside wires, purchasing your motor generator or economizer with that end in view—with a 220 volt motor. Mercury arc rectifiers may be used for either 110 or 220.

The location of the operating room switchboard cabinet will necessarily be determined by local conditions, but use care to place it conveniently.

There is nothing to be gained by making things inconvenient for the operator, and there is much to be lost by doing so.

As to the main operating room fuses, I would suggest they be placed as shown in Fig. 94, rather than on the other side of the switch. Inasmuch as the operating room feed wires, including the operating room main switch, is protected by fuses on the main switchboard, there is no necessity for protecting it further, and it is more convenient to install fuses at B if the fuse block is "dead" than if it be "alive."

In some cities the power company will not allow the neutral of a three-wire system to be run to the operating room. This compels the use of 220 volts which, if rheostats are used, is very wasteful indeed. The reason for this is the heavy unbalancing effect (already explained) of the projection arcs. It is quite possible that this unbalancing effect might be very serious, from a power company's point of view, particularly in a small city where there are a number of moving picture theatres and the power company's generators likely to be pretty heavily loaded. Supposing, for instance, one side of a street main supplies five moving picture theatres, each having two machines connected to the same side of a three-wire system. Now suppose it happens, as it might easily happen, that the operators in all five theatres chanced to be changing from one machine to the other at the same time, and all struck the arcs of their idle machines at the same moment. This would mean, assuming that all were pulling 40 amperes at each arc, a total unbalance of 400 amperes (five theatres, two arcs to the theatre), which would probably put everything else attached to this same generator out of business, at least temporarily.

Even if these five theatres each had their two arcs on opposite sides, when only one arc was burning it would mean an unbalance load of $40 \times 5 = 200$ amperes, so you see the light company is perfectly justified in demanding that only the outside wires be used. But *this does not hold good if current is taken through resistance.* In that event the changing to the two outside wires would have no effect at all, except to load *both* generators of the system that much more heavily. Instead of having one generator pulling an unbalanced load of 400 amperes, as before set forth, if connected to the two outside wires through resistance *both* generators would be pulling a load equal to 400 amperes at 110 volts, when all arcs were burning, therefore the only thing gained is a

big additional (double) and entirely useless waste of electrical energy.

What the light company has the undoubted right to do is to demand that the projection lamps of the theatre be connected to opposite sides of a three-wire system when

Figure 95.

current is taken through rheostats, and if an economizer, motor generator, rotary converter or mercury arc rectifier be used that the supply be taken from the outside wires.

In Fig. 95, the typical, and in some ways excellent operating room of the Park Theatre, Bangor, Me., is illustrated. It will be observed that the projection machine circuits are led under the floor and up to an outlet immediately under

the lamphouse, which is exactly as it should be. The vent flue seems to be of ample size and well located. The switchboard is apparently neatly put together, but should have a metal cabinet to protect it. The switch and voltmeter and ammeter near the ceiling at the right govern a 5 k.w. motor generator set.

The work bench is made of wood, which would be objected to in many cities, though the objection has no real basis. There is about as much danger in a wooden work bench in an operating room as there is in a pile of sawdust in an ice house. The fuse links of the shutter cord are so located that they would be of slight value in case of fire. There is no evidence of toilet conveniences, though it is possible they may be placed near-by but outside the operating room. The tools would look better in a neat rack over the work bench, instead of lying on the bench.

In Fig. 96, Fig. 97, and Fig. 98, we see three views of a most excellent operating room installation at the Monarch Theatre, Cleveland, Ohio. In this installation there is little to criticise. The fire shutters are hung from a master-cord, which is correct practice. As shown the master-cord fuses are wrongly placed, but I am informed that since the picture was taken the fuses have been carried down under the magazine and placed over the machine apertures on brackets. What tools are in sight are neatly hung up on the wall. The conduit is not buried in the floor, ceiling or walls as it should be, but this could not be avoided as the walls of the room are of hollow tile and the local laws will not permit a conduit to be placed inside of that kind of operating room wall. It is true that a conduit on the face of the wall serves the purpose just as well from an electrical standpoint as it would were it buried in the wall, but it looks bad and spoils the finish of the room. There is a wash basin, with cold and hot water, but an apparent absence of seats for the operators, and that I cannot agree with.

I believe the operator is much more likely to remain at his machine, where he belongs, if there is a comfortable seat provided, and surely he will do as good or better work when seated at his machine than when running around the operating room, letting George (the motor) project the picture.

The room is 10 x 15 feet, with a ceiling 10 feet at the walls and 12 feet in the center where there is a 36 x 40 inch vent flue, in which is an 18-inch G. E. exhaust fan. In the rear wall, only part of which is shown, are two windows

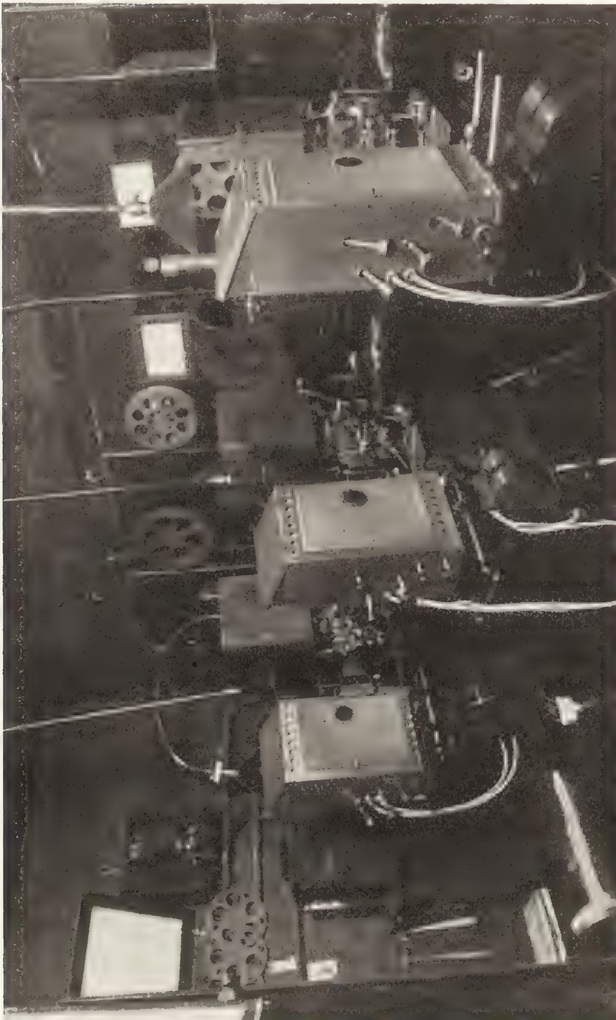


Figure 96.

Figure 97.

30 x 40 inches, each having a 16-inch fan set in its center. The windows open on a 10-foot court, and are metal instead of glass.

Each machine is connected to two rheostats in multiple, and it will be noted the rheostats are placed near the ceiling, where they should be. There is a voltmeter and an ammeter, but these two instruments are poorly located, as the operator, when standing at the machine, would have to turn round to see them, and that is not good. There are three projectors, which eliminate all possibility of

Figure 98.

trouble from a break-down. The observation ports are 8 x 12 inches. The walls are of tile and brick, 18 inches thick, with a ceiling of steel roofing with an air gap of 3 inches above and then metal lath plastered. The floor is of cement, built up on the ground, covered with battleship linoleum one-fourth-inch thick. The floor of the operating room is only 3 feet 6 inches above the main floor of the theatre. The lens ports are 6 feet 8 inches from the main floor, which places the lens in almost perfect line with the center point of the screen. The cabinet next to the sink contains controls for the heating system, the center one the switches for the theatre lights, and the third the fuse board

for the operating room. There are two sets of No. 6 wire running to each machine, each set connected to separate fuses. The machine switch of the two outside machines is double-throw, so that by throwing the switch over a new set of fuses is cut in. We see the corner opposite the sink in Fig. 98. The bank of six lamps and the batteries are the business end of the safety lighting system required by Ohio law. It automatically lights small, low voltage lamps in the auditorium if anything goes wrong with the main

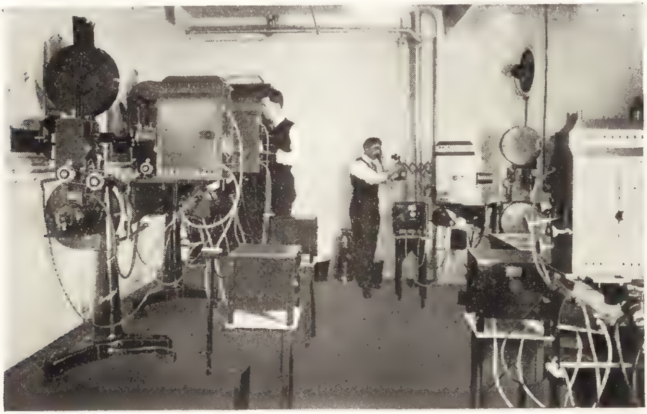


Figure 99.

circuit, thus preventing the plunging of the auditorium into darkness.

I am informed that the card index shown immediately under the cabinet contains more than two thousand questions and answers on operating and the things allied thereto. The typewriter is used in connection with the card index. Notice the extra parts neatly arranged on the wall; the program slate; the extra reels and wire; the oil cans and the electric battery flash lamp.

This installation is the work of Howard W. Codding, who, by the way, was one of the organizers of the Cleveland operators' union. Judging from these pictures, Brother Codding is a thoroughly capable, enterprising and progressive operator, and one not merely satisfied to be able to

draw his Saturday night's pay, giving the least possible mental and physical effort in return.

Later: I am informed that there are comfortable chairs for the operators, though they do not show in the pictures.

Fig. 99 shows the operating room of the Pathe projection room at the American headquarters of that company.

I have used these operating room illustrations for two reasons: first, they are excellent of their kind, and I believe will serve to offer suggestions to others planning similar installation; second, to mildly criticise the faults shown, but I wish it understood that these installations are nevertheless good, and good ones to copy, too, with the faults mentioned eliminated.

With regard to the projection circuit, when it cannot be carried under the floor it should by all means be carried through and above the ceiling, if possible, or if that cannot be done then along the surface of the ceiling to a point just to the left of the projector lens hole, and thence down the wall and back, either along the left side of the machine or along the floor, according to individual preference, to an outlet located under the lamphouse. Some of these various methods are shown in the illustrations. There is no rule which can be made to apply to all installations.

As a rule inspectors require that all switches, except those of the inclosed type, and all fuses be inclosed in a metal cabinet, and it undoubtedly does add an element of safety, since there is always a chance of something inflammable falling against an open switchboard and causing trouble, or of the operator himself accidentally coming into contact with it and receiving a bad shock or burn.

With modern projectors the operating switch is invariably a part of the machine, and located under or beside and below the lamphouse. These switches must be of the inclosed type—inclosed in a sheet metal casing.

Double Throw Connection.—*Two projectors should never be connected through a double-throw switch with the supply attached to the center contacts, so that it is necessary to extinguish one lamp to light the other,* except in cases where current is taken through a single motor generator or rectifier of insufficient capacity to supply both lamps. In that event it is well to make that sort of connection, but, on the other hand, it is advisable where that condition prevails to arrange so that the idle lamp may be operated through a rheostat taking current directly from the supply lines

ahead (on the street side) of the motor generator or rectifier.

This sort of connection, shown in Fig. 100, is entirely practical and not at all expensive to make. In practice I think the change from rheostat to compensarc could be made without breaking the arc. The idle lamp would be lit up, using current through the rheostat, about two or three minutes before the reel on the other machine was ended and at the changeover the operator would quickly throw

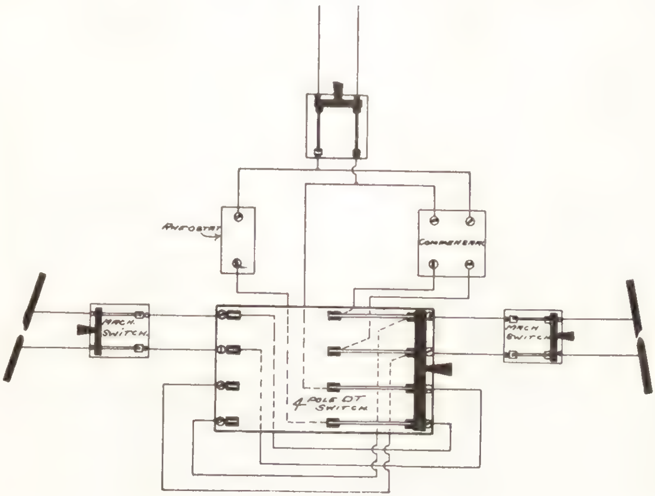


Figure 100.

over the four-pole switch and pull the machine table switch on the machine which had finished its task.

Except under the circumstances just named every machine circuit should be entirely independent of every other circuit. Connect every projector lamp and every stereo lamp entirely independent of every other lamp and you will avoid trouble and annoyance.

Polarity Changer.—Where the supply is taken from a small D. C. plant it sometimes occurs that when dynamos are changed the polarity changes, which requires the instant switching of your own wires to bring the positive back to

the top carbon. This may quickly be accomplished by the installation of a double-throw double-pole switch, such as is seen in Fig. 101. Throwing this switch over changes the polarity of the wires. The cross wires should be pro-

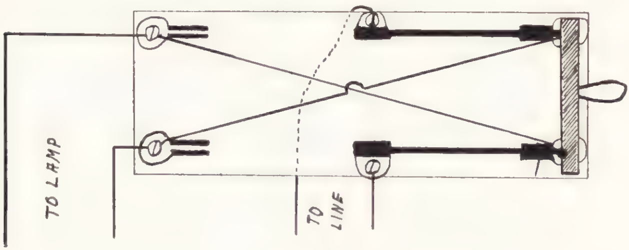


Figure 101.

tected by flexible insulating tubing in addition to their own insulation.

Fig. 102 is a diagram of a combined polarity switch and fuse changer. By throwing switch A a new set of fuses

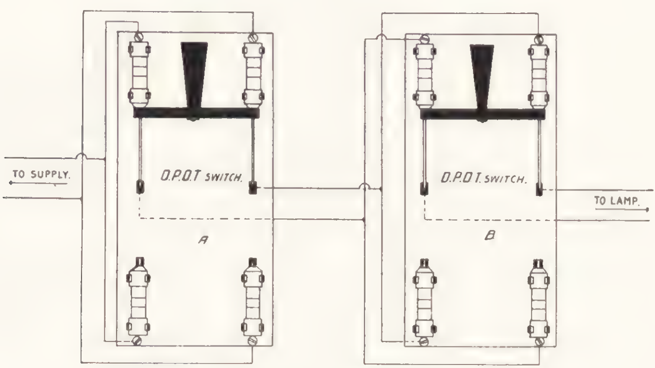


Figure 102.

is cut in and by throwing switch B the polarity at the arc is changed.

Connecting to Two Sources of Supply.—For various reasons it is frequently desirable to make connection to two separate sources of electrical supply. One may have one's

own light plant, but wish, in case of accident, to be able to instantly connect to the wires of the city plant. This may readily be done, but due to varying conditions details may vary widely in different cases. Suppose we have a house plant delivering direct current at 110 volts, while the city plant produces A. C. at 110 volts; both systems two-wire. The problem then is simple.

Install a double-pole, double-throw switch, as per Fig. 103. The house plant being D. C., we shall not need nearly so much amperage from it as would be necessary for equal screen illumination with the city plant, A. C.; therefore, we install two rheostats, A and C, the lower one, A, to be used with a D. C. house plant. B is a double-pole single-throw

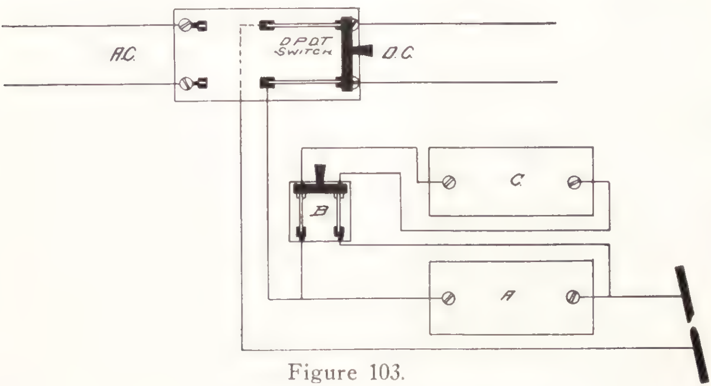


Figure 103.

knife switch which is open when D. C. is in use, so as to use only rheostat A. When we throw over to the A. C., however, we close switch B, thus cutting rheostat C in multiple with rheostat A. Rheostat C should have capacity sufficient to build the combined amperage of the two up to that necessary for good illumination of the screen. Suppose we use 35 amperes D. C. In order to secure anything like the same curtain brilliancy rheostat C must have capacity sufficient to deliver 25 amperes which, combined with the capacity of rheostat A, will give 60 amperes at the arc. But we must remember that, owing to the shorter A. C. arc, hence the less arc resistance, rheostat A will deliver somewhat more current on A. C. than it will on D. C., the voltage of the supply being the same in both cases. We

will probably, therefore, be not far out of the way if we have rheostat C of capacity to deliver 20 amperes at the arc.

We may, however, instead of this, install a transformer (economizer, inductor, compensarc, etc.), in place of rheostat C, Fig. 103, and with a triple-pole double-throw switch, wired as per Fig. 104, cut out resistance A, Fig. 103, substituting the economizer therefor. Merely throwing the switch over

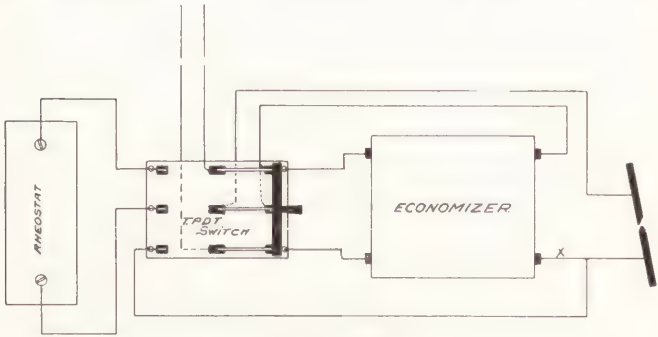


Figure 104.

would then change from rheostat to transformer, and vice versa, though the transformer would be "alive" in the sense that you could get a shock from it. But this would do no harm. If you wish to "kill" the transformer entirely when

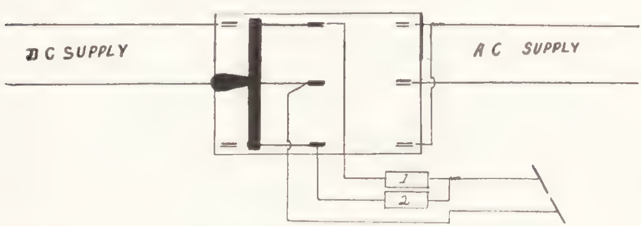


Figure 105.

using the rheostat, it may be done by installing a S. P. S. T. switch at X, Fig. 104.

Please understand there are many other switch arrangements possible. Such things may be done in many ways. Those suggested merely illustrate two possible methods. Another and still better way to cut the two rheostats in

multiple, Fig. 105, is by means of a triple-pole, double-throw switch.

A careful tracing out of the connections in Fig. 105 will show that when the switch is thrown to the A. C. supply side the two rheostats are in multiple, while when the D. C. side is in use only rheostat 1 is working. Should the supply voltage be higher on one system than on the other, a higher voltage rheostat could be substituted for A, Fig. 103, and rheostat C be made of such capacity that it will bring the amperage up to normal when on the lower voltage.

Grounds

ONE of the most puzzling things to the novice, and one not too well understood by many experienced operators, is what is termed a "ground," meaning a contact with some current carrying material by means of which the current can escape from one wire of a circuit into the ground and through the ground to some point where a wire of opposite polarity attached to the same generator has contact with the ground, or is "grounded." Incidentally, when a conductor of current, such, for instance, as the metal of a lamphouse, has electrical connection with either side of the circuit, that side of the circuit is said to be "grounded to the lamphouse," even though the lamphouse itself is insulated from the opposite polarity, so that no current can flow. This is, however, not a ground in the true sense.

The neutral of all Edison three-wire systems is grounded to earth. This is a true ground, and if an accidental ground occurs on the other wires of the system, the current will return to the dynamo through the earth, and thus form a short circuit, blowing the fuses protecting the circuit on which the ground occurs.

And now right here let me make it clear that *the somewhat common belief that current seeks to escape from the wires into the ground is wrong, except when by so doing it can find a path to a wire of opposite polarity which is attached to the same dynamo.* Let me also emphasize the fact that the current generated by one dynamo will not seek the opposite polarity of another dynamo, but only that of its own generator.

Electric current has absolutely no affinity whatever for anything under the sun except a wire of opposite polarity attached to the same generator.

If the positive or negative wires of a generator carrying ten thousand volts, or for that matter fifty thousand, were thoroughly and completely insulated (a condition never found in actual practice) you could stand with your bare feet on wet ground and handle a wire carrying the full voltage with your bare hands without any danger whatever, but if you attempted to do this and the wire of opposite polarity be grounded at any point, the current would instantly leap through your body into the earth, follow the path of least resistance to the point where the other wire was grounded, and enter it; or, lest we become confused, assuming that current flows from positive to negative, if you held the negative wire, then the current would leave the

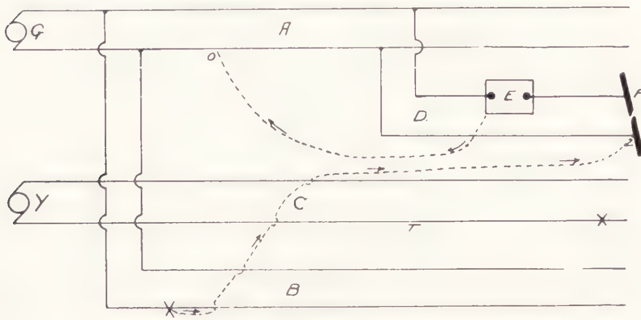


Figure 106.

positive, enter the ground, pass through the ground to your feet, up through your body and into the negative. The effect, insofar as shock be concerned, would, of course, be identical, regardless of which way the current might flow. I emphasize this because some are puzzled by the fact that when they touch a negative wire they get just as heavy a shock as they do when they touch the positive.

Examining Fig. 106, A is a circuit attached to dynamo G, and B a subsidiary circuit branching from it. Now, let us assume that the system is grounded at point Z, in the lower or negative carbon arm, and at point X on the positive of the subsidiary circuit. In this case the current would leave the positive at X, travel through the ground, seeking the path of least resistance, which might lead it through some distance, to point Z, where it would enter the carbon

arm. You will observe that it does not enter circuit C, attached to generator Y, although the negative of that dynamo is grounded, let us assume, at T. The curves in the line are merely designed to show the devious path the current may traverse in seeking the path of least resistance.

Again, let us suppose rheostat E to be grounded, it being on the true positive of an Edison three-wire system, or the positive of an insulated system, and that a ground on the neutral or the negative exists at O. The current then leaves your rheostat, passes into the earth and follows a water main, or possibly a gas main, or perhaps the earth itself to point O, where it finds what it is seeking, viz.: a point at which it can get into the negative wire..

With regard to the three-wire system grounding, it is a great puzzle to many. Let me say, in the beginning, that there are two kinds of three-wire systems, viz: the Edison system, in which the neutral is always thoroughly grounded at the generator and at other points, and the three-wire system in which the whole system is insulated. The reason for grounding the neutral in the Edison system is to prevent any possibility of the conduit in buildings being charged at 220 volts, or, to put it in electrical terms, to limit the difference of potential between any wire and the conduit system in buildings to 110 volts. The insulated three-wire system is, so far as the writer knows, only used for small plants.

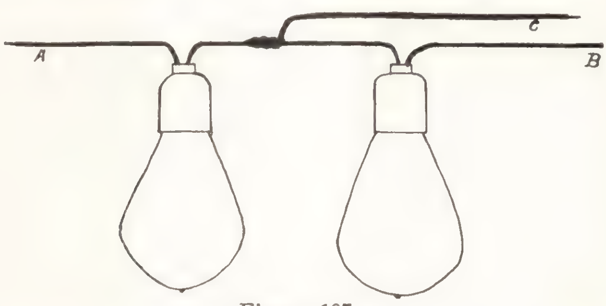


Figure 107.

With the Edison three-wire system your test lamp will not show a light from ground to neutral, and if your neutral carbon arm should be grounded there will be no effect, unless the rheostat is in the neutral wire, in which case the

fuses may blow when the arc is struck, by reason of the fact that the striking of the arc completes the circuit through the ground, as indicated in Fig. 106, thus eliminating a portion or all of the rheostatic resistance, the amount eliminated depending upon how heavy the ground may be.

It might incidentally be mentioned that, theoretically at least, it would be quite possible when using the Edison three-wire system to locate the rheostat on the outside wire, remove the insulation from the carbon arm of the lamp to which the neutral is attached, disconnect it from the wire and thoroughly ground the carbon arm, whereupon the arc would operate the same as though it was connected up to the system. The above is merely cited as a curiosity, and not because it is really a practical thing to do.

Gounds may be tested for with a test lamp. This may be a single lamp, of the voltage of your system, to which two wires of convenient length are connected, or when using the Edison three-wire system, the test lamp may be made up as per Fig. 107. The lamp combination used in Fig. 107 is designed to be used on either 110 or 220 volts.

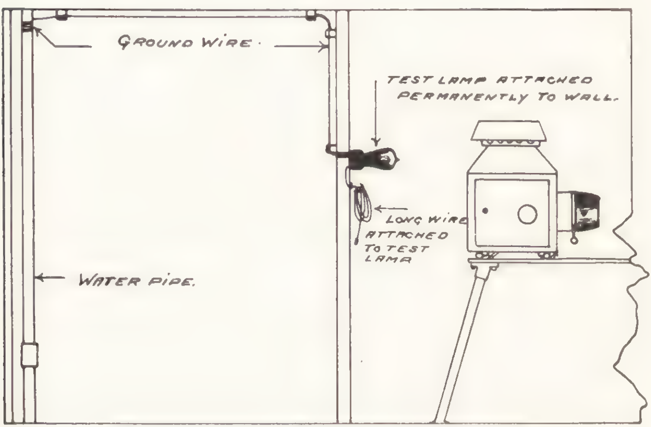


Figure 108.

On 110 volts, wires A and C only should be used, but on 220 use wires A and B, the lamps being 110 volt globes, preferably of low candle power, though standard lamps will do. If you are not using 110 or 220 volts, then you will, of

course, use lamps of whatever voltage your system may happen to be.

It is highly desirable to have a permanent, known ground in the operating room, and this may best be established by either attaching a copper wire, No. 22 or larger, to a water pipe, or else by soldering the end of such a wire to a copper plate not less than one foot square, and burying the plate, embedded in powdered coke, in the ground deep enough to secure its contact with moist earth. Having established the ground by either of the above described methods, carry the other end of the wire through the wall of the operating room at any convenient point and attach a binding post at its end. This forms a permanent, known ground. To attach the ground wire to the water pipe the best method is, using a file or emery cloth, to polish the pipe perfectly clean and bright for one or two inches of its length, and then, first having stripped the insulation from four or five feet of the end of the wire, and scraped the wire perfectly clean, wrap the same many times around the pipe tightly, and fasten it securely in place, but be sure that the wire is held tightly to the pipe. Having finished this, we will proceed to attach the test lamp socket firmly to the wall, in any convenient manner, close to the end of the ground wire, and join one of its binding posts thereto by means of a short piece of wire. Now cut a piece of insulated wire (braided lamp cord is excellent for the purpose) long enough to reach from the other binding post of the test lamp to any point in the operating room where you are likely to want to make a test. Attach one end of this wire to the other test lamp binding post and you will then be in a position to make a ground test instantly at any time, simply by touching the lead wire from the lamp to the object you desire to test, the lead wire being, of course, kept coiled up on the wall beside the test lamp when not in use, all of which is shown in Fig. 108.

It is quite possible the object to be tested may be grounded and still not light the lamp, by the reason of the high resistance of the ground not allowing sufficient current to pass to heat the filament, but this kind of ground will be detected, nevertheless, by reason of the fact that the end of the wire will show a spark when the contact is broken. For this reason it is always better, when possible, to test in a moderately dark room. With this arrangement the operator can test his aparatus every day without trouble or inconvenience.

However, you must bear in mind that *when using an Edison three-wire system you cannot test any apparatus connected only to the neutral wire with a test lamp,* because they are permanently grounded with the neutral. In testing with a dry battery it is not necessary to use a bell; just connect two wires to the battery, and make your test. If there is a ground there will be a spark. It is better, however, to use two or more batteries connected in series.

With the insulated three-wire system the test lamp acts the same as with the two-wire system.

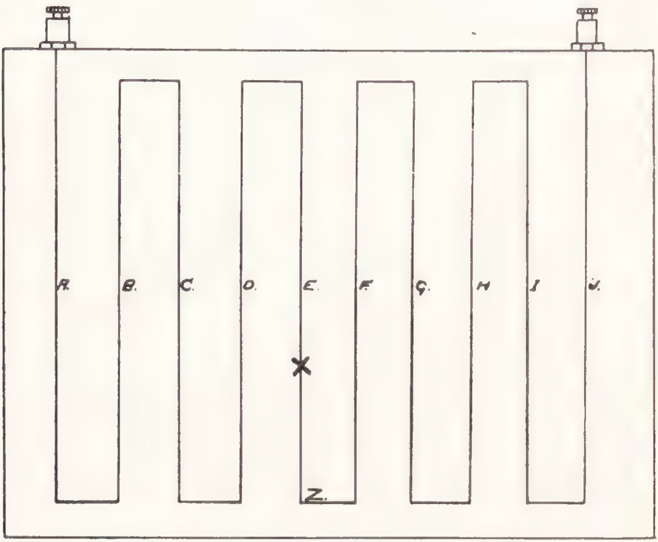


Figure 109.

Locating a grounded coil in the rheostat is a deep, dense mystery to many operators, but it really is a very simple matter. Fig. 109 is a diagrammatic representation of a rheostat; A, B, C, D, etc., indicating the coils or grids, coil or grid E being grounded to the frame at X. Assuming that we wish to test this rheostat to find out whether or not it is in good order, using a magneto or bell and battery, first touch the binding posts with the two leads from the bell and battery, or magneto. If you get a ring it indicates that the circuit is complete; that is to say, no coil is broken or

disconnected. Next touch one binding post and the outer casing or frame of the rheostat. If you get no ring then the rheostat may be considered in good order, except for one thing which cannot be located with a bell or test lamp, viz., two coils being sagged together so as to eliminate a part of the resistance without breaking the circuit.

The rheostat may be tested with a test lamp in a number of different ways. First, assuming the rheostat to rest upon a marble slab, or other insulating material, with the current on, touch your test lamp to the frame of the rheostat and to the wire of opposite polarity. If you get a spark, or light, the coils or grids are grounded to the frame, and the ground can be located as hereinafter described. Another way would be to disconnect the wire leading from the rheostat to the lamp from the rheostat binding post and, with the switch closed, touch the frame of the rheostat with one test lamp lead and the wire which has just been disconnected with the other, the arc lamp carbons being "frozen," i.e., in contact with each other. If you get a light or a spark there is a ground; if not, there is none. Still another way, again assuming the rheostat to rest on an insulating shelf, disconnect one of the wires from the rheostat binding post and, with the carbons of the lamp frozen and the switch closed, touch the disconnected wire end to the frame of the rheostat. If you get a spark there is a ground.

Now suppose you have applied one of these tests and find there is a ground in the rheostat, indicating that one of the coils is electrically connected with the frame. How are you going to locate the particular coil or grid at fault? This is a point which puzzles so many operators, yet it is as simple as a, b, c, when you come to examine it in the light of common sense. Close the switch, and, if you are using a test lamp, attach one test lamp lead to one of the rheostat binding posts. Now attach the other test lamp lead to the frame of the rheostat, and, beginning at the end farthest from the binding post the test lamp lead is attached to, disconnect the first coil, which we will assume to be coil A, Fig. 109. The light still burns. Disconnect coils B, C, and D in turn. The light still burns. Disconnect coil E and the light goes out, because you have removed the ground. You will, therefore, proceed to examine coil or grid E and locate the trouble, which may and probably will be due to a ground through the insulation of the connection at Z.

Where a rheostat consists of two blanks of coils or grids considerable labor can be saved by disconnecting one side

or bank from the other, and then testing each, as a whole, to find out which half the ground is on. It is then only necessary to disconnect the individual coils on the defective side.

It is always advisable that the projection machine lamphouse and mechanism be grounded to the metal of the operating room, and the whole may, or may not be thoroughly and permanently grounded to a water pipe. The reason for grounding the projection machine, especially if it be an all metal one, to the operating room metal work, lies in the fact that if the machine be insulated from the metal of the operating room and the lamp should become grounded to the metal of the lamphouse it would charge the whole mechanism, and, should the operator, when putting a reel in the magazine, touch both the magazine and the metal of the operating room with the reel, there would be a spark which might set the film on fire.

There is no real necessity for grounding the metal of the operating room; it may or may not be done, as best suits the ideas of the individual.

Testing for ground is, after all, a matter of plain, horse sense, and anyone can do it if he understand electrical action.

THE PROJECTOR

The Lamp House.—Of late projection machine manufacturers have awakened to the importance of a carefully constructed lamphouse, and the later models of all standard projectors leave very little to be desired so far as the lamphouse be concerned. In the early days, when it was the exception to use in excess of 25 amperes for projection, and 30 was about the limit, no one paid much attention to the lamphouse. It was a little, contracted affair, built of russia iron, single thickness, which merely served to confine the light, or some of it, and hold the condensers—after a fashion.

The lamphouse of the modern projector is, however, in some instances, a double walled affair, lined on the inside with insulating material. Its proportions are imposing; its ventilation is very carefully planned, and in fact the whole outfit is excellent and complete, and probably will not be very largely improved in the future, except as to the condenser mount, which still leaves considerable to be desired.

The ventilation of the lamphouse is of extreme importance, particularly where high amperage is used. If your lamphouse is of the type having screens over the ventholes, either above or below, it is very important indeed that these screens

be kept perfectly clean, since if the screen, either above or below, clogs up, then ventilation is impeded and an excessive heat is set up inside the lamphouse. This has a double effect. First, it tends to overheat the condensers—to raise them to an unnecessarily high temperature, which very largely increases liability to condenser breakage through sudden and extreme contraction of the lens, especially when the lamphouse door is opened to trim the lamp immediately after finishing a reel.

The lower the temperature in the lamphouse is kept the less will be the likelihood of condenser breakage.

That is a plain, common sense proposition everyone ought readily to understand. It also is very plain that the more open and free the ventilation of the lamphouse is the lower will be the temperature of its interior.

The second effect of lack of ventilation is that by increasing the temperature inside the lamphouse the lamphouse itself radiates more heat, thus increasing the discomfort of the operator in warm weather.

The core of the carbons contains a substance known as water-glass, and the residue of water-glass is a white ash which coats the interior lamphouse walls and very quickly clogs the holes in the screen at its top. Therefore it behooves the operator to *clean the top screen every day*. It is not a dirty job if it is done every day, but if you try to clean it when it has not been cleaned in a long while you had better take the entire lamphouse off and take it out of doors to clean it or you certainly will have a nasty mess in the operating room.

Best Method of Ventilation.—The best and most feasible scheme for ventilation is one recommended by the Projection Department of the *Moving Picture World* more than three years ago. It consists of running a 3 or 4 inch metal pipe from the top of the lamphouse to the open air, or up into the operating room vent flue. This is now provided for in the Power, Edison, Simplex and Baird lamphouses of late design by an opening left for that purpose.

The idea is set forth in Fig. 110. This pipe carries away much of the heat of the arc, reduces the liability to condenser breakage and renders the position of the operator far more pleasant through the hot summer months. It has the hearty indorsement and approval of the Projection Department of the *Moving Picture World* and of the author of this book.

I would recommend its installation in all operating rooms, but don't just run a short piece of pipe up a foot or so above the lamphouse. It would be perfectly safe to do that, but it would not carry the heat outside the room, and, moreover, would not be approved by the authorities in cities. *Run the pipe out to the open air or up into the operating room vent flue.* If this is done it need not be capped with a screen, because in any event it will not be less than 5 or 6 feet long, and by no stretch of the wildest imagination would a spark from the electric arc reach such a distance as that. If it is necessary to swing the lamphouse over to the stereopticon,

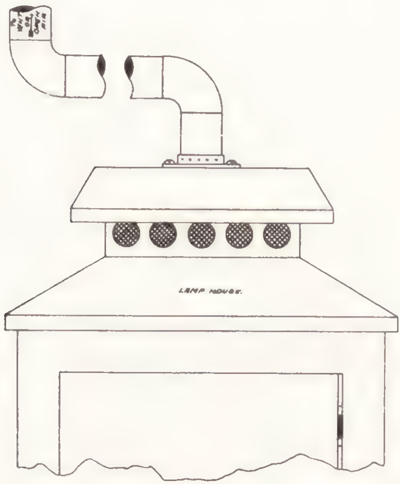


Figure 110.

that can be readily provided for by putting in a swing joint or a slip joint, or a combined swing and slip joint. Most of the leading machine manufacturers have already made provision so that this sort of vent pipe can be attached to their lamphouse. Where such provision is not made the pipe may be attached by cutting through the top of the lamphouse and attaching it thereto with a suitable flange.

In most cities the authorities require that the back of the lamphouse be entirely inclosed. This is pure, unadulterated nonsense, but nevertheless when it is the law it must be complied with. Where the law does not require its closure,

however, I recommend that the entire back of the lamphouse be left open, unless such a pipe as already described is installed, in which case there will be ample ventilation without removing the back.

Lack of ample ventilation in the lamphouse causes moving picture theatre managers in this country a large sum in condenser breakage every day. I should say this item alone would run to at least two and perhaps as much as five hundred dollars a day, in the United States alone, meaning that that amount of condensing lenses are broken that would not be broken if the lamphouse had ample ventilation.

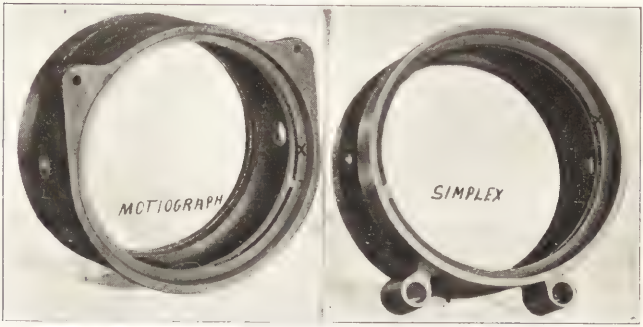
Keep Your Lamphouse Clean.—The careful, painstaking, competent operator will keep his lamphouse clean. It does not look well to find a half inch of carbon dust, dirt and pieces of broken carbons lying on the floor of the lamphouse. It does not give one a good impression of the man in charge. It is not the workmanlike way of doing things.

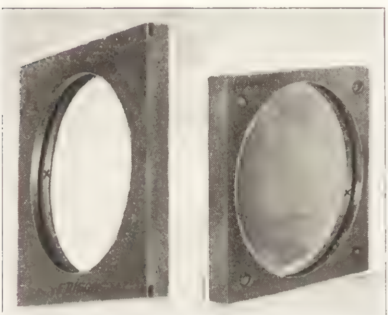
The rods upon which the lamphouse slides, if it slides over to the stereopticon, should be kept lubricated. When your lamp has the desired angle, if the lower carbon jaw comes into contact with the front wall of the lamphouse you should line the front wall at that point with one-eighth inch asbestos millboard, which may be fastened to the wall by punching four screw holes and attaching the board with small, short stove bolts. If your lamphouse is of the old, unlined type it is also an excellent plan to rivet one-eighth inch asbestos millboard to the left hand wall, or door, opposite the binding posts of the lamp. Many annoying grounds are caused by a stray strand of the asbestos-covered lamp leads protruding and making electrical contact with the lamphouse.

Arc Projector.—Modern lamphouses are provided with a properly located arc observation window of ample dimensions, fitted with glass of a color combination enabling the operator to look directly at the arc without the least eyestrain.

Many operators, however, prefer to project a picture of the arc on a white screen pinned to the operating room wall. This is very easily done, as follows: With a drill or punch not exceeding one-thirty-second of an inch in diameter, make a hole in the left hand wall, or door of the lamphouse *exactly opposite the arc when it is in proper position.* Through this hole a picture of the arc will be projected to any white surface held a short distance away, but the image will be upside

down. The picture may be improved by placing in front of the hole a small piece of a broken condensing lens, or any small lens you may happen to have; an old spectacle lens will often serve. It is also possible to project a front view of the arc on the front of the upper magazine of the projector by punching a small hole in the front wall of the





ELBERT HOLDER
Figure 111.

lamphouse just above the condenser casing. Don't have the hole too large, however, or the image will not be sharp.

Condenser Holder.—It is only of late that any particular attention has been paid to the condenser holder, but several holders have now been evolved, the intelligent use of which very largely eliminates condenser breakage.

Condensers break because one part of the lens is thin and another part is quite thick. Therefore when the lens is subjected to heat, the edge, or thin part, heats up very rapidly as compared to the thicker center. Hence the edge of the lens expands and contracts much more rapidly than its center.

The theory of these improved condenser holders is that by providing a heavy band of metal at the edge of the lens there will be a retarding effect in the metal which will hold down the temperature of the edge of the lens when it is heating up, and hold up its temperature when it is cooling off, so that the center and edge of the lens will cool down approximately at the same speed, and thus expansion and contraction will be fairly equal and breakage very nearly eliminated. The theory is correct, as has been proven in hundreds of instances where these holders have been installed.

In Fig. 111 we see four styles of the Elbert holder illustrated. I think the idea is fairly well conveyed by the pictures. The lens is held in place by spring steel ring, marked X in the illustration. The Elbert holder may be used for both the front and back lens, and in fact as made for the Simplex and Motiograph it does hold both the front and back lenses. The Power and Edison holder is made for one lens only, but a pair may be secured, if desired, so as to hold both lenses.

PREDDY HOLDER
Figure 112.

In Fig. 112 is shown the Preddy holder, also an excellent and very efficient device for holding the rear lens of the condenser. It is not, however, designed to hold the front lens. Fig. 113 shows the method of its installation and the details of its construction. It is made of cast metal.

No doubt machine manufacturers will themselves add this feature to their projectors in the near future. In fact some of them have already done so, in a limited way. *I would strongly advise all theatre managers to have their lamphouses equipped with one of these devices, particularly if they are using high amperage. To those troubled with condenser breakage these holders will save their cost in a very short time.* Both the Preddy and Elbert mounts are excellent and easy to install.

In ordering give the kind and model of your projector. Don't forget that part, for it is very necessary.

The Lamp.—Light is the very foundation of projection, and the lamp is a most important factor in the production of good light. In fact, the production of the best possible projection light is entirely out of the question where a poor lamp is employed, or a lamp that is dry, loose and "wobbly," or so tight in its joints, or so dry, that you can scarcely move its adjustment wheels.

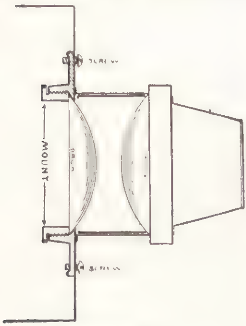


Figure 113.

In the past two years there has been an enormous improvement in the design of projector lamps; in fact it is only within that time that we have had anything like an efficient lamp. The manager who is compelling his operator to use an old antiquated type of lamp is doing a very, very foolish thing. He is "saving at the spigot and losing at the bunghole." He is injuring the results on his screen every hour he runs, merely to save a few dollars in the purchase price of a good lamp.

Many an operator is producing poor results on the screen for no other reason than (a) he has an old out-of-date lamp, not having the proper adjustments; (b) his lamp is not properly lubricated; (c) it has too much lost motion and shakiness; (d) his lamp is too tight or too dry to allow of his making proper adjustments of the arc; (e) its carbon jaws are rough and dirty, thus preventing good contact between the carbon and metal.

It matters not how excellent the lamp itself may be, unless it be kept in proper condition and properly lubricated it cannot be handled properly and, therefore, the operator cannot make the fine adjustments of his arc which are absolutely necessary to good projection.

The lamp should be taken apart at stated intervals and *thoroughly lubricated with powdered graphite.* It is of little use to lubricate the lamp with grease or oil, since it is quickly burned off or dried by the heat, besides making a smudge inside the lamphouse which is likely to cloud the lenses.

Managers should in all cases provide plenty of good, powdered graphite, and compel, if necessary, their operators to use it regularly on the lamps.

Seventy-five cents will get a can large enough to last for a year of more, unless it be wasted. By all means get a can at once unless you already have it. Powdered graphite may be had of up-to-date dealers. If you fail to get it elsewhere it may be had of the Picture Theatre Equipment Company, 19 West Twenty-third street, New York—20 cents, by parcel post. This company has it both dry and in a paste form—both good. Say which you want when ordering.

Operators should make it a practice to take their lamp entirely apart, except the insulated joints, which should never be disturbed, once a week if they are running a twelve-hour show and using heavy amperage, or say once in two weeks if the running time does not average more than five hours a day. Take out all the screws, dip them all in oil, wipe them off clean and dip them in a box of graphite; also smear all the moving parts with oil, wipe the oil off and rub the parts in graphite; the oil is merely to make the graphite stick. Therefore *all surplus oil should be wiped off clean.* Don't wipe the parts off after dipping them in graphite. Just shake the graphite off and put the parts back. The more graphite adhering to them the better. If you have never done this you will be astonished at what a difference it will make in the handling of your lamp and your arc. You will be surprised at how much better you can gauge your light.

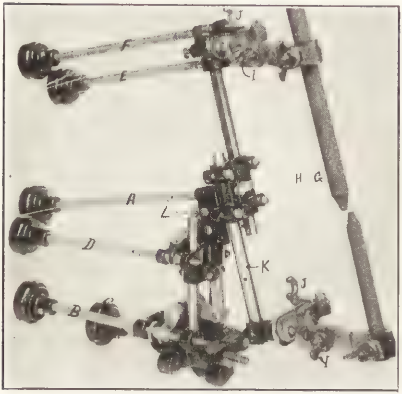
Make it your practice to take out the carbon clamp screws every day before starting the run, and lubricate them with graphite as before set forth.

Do this and you won't need to twist them up with a plier; in fact, if you have been using unlubricated clamp screws you will most likely crush the first carbon or two you put in.

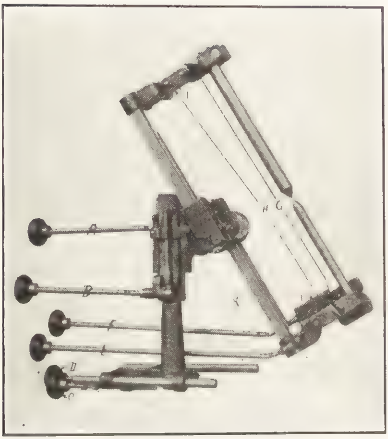
On Pages 270, 271, and 272 will be found illustrations of the lamps of the various leading projection machines. These are given in order that the operator may examine the general make-up and decide for himself which is best. To this end certain letters have been incorporated.

(a) Being the carbon feed handle; (b) the handle with which the lamp, as a whole, is raised up or down; (c) the handle by means of which the lamp is pulled back or shoved ahead; (d) the handle by means of which the whole lamp is swung from side to side; (e) the handle by means of which the upper or lower carbon is swung to one side in order to accomplish the side-lining of the carbons: (f) the handle by means of which the upper or lower carbon is shoved ahead or pulled back in order to govern the formation of the crater; (g) the carbon clamp screws; (h) the insulation;

(i) the means by which the carbon arms may be tilted or angled; (j) the hooks to hold the cables; (k) the means by which the whole lamp is angled.



POWER'S



EDISON SUPER

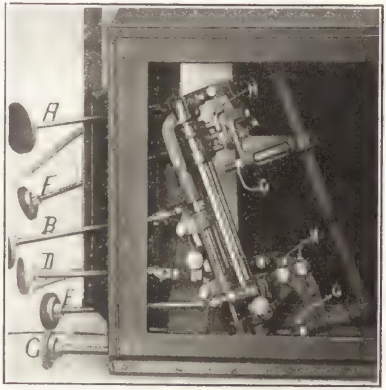
Figure 114A.

It will be noted that these lamps are far more substantial than the older types. They accommodate 12-inch carbons above and 6-inch below. They are, without exception, well made mechanically, and have all the necessary adjustments to enable the operator to force his arc into any desired position. The old nuisance of weak carbon clamps has been done away with. It is rare indeed to hear of an operator breaking a carbon clamp on the newer type of lamp. The small rack bars have given place to bars of generous dimensions, and, in fact, the modern lamp leaves very little to be desired.

It is extremely important that the inside of the carbon clamps of your lamp be thoroughly scraped out once a week; oftener if high amperage is used.

Through continued use the inside of the carbon clamp gradually becomes rough, pitted and dirty. If left uncleaned it is but a question of time when it will be practically impossible to secure good contact between the carbon and the

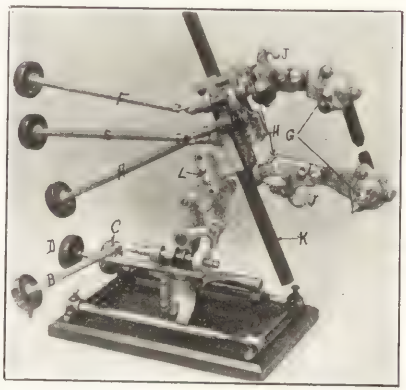
metal. The proximity of the arc operates to create high temperature in both the metal and carbon and when you add to this the heating effect of poor contact the result is very bad indeed. Needling of the carbons also may be often traced to this cause. The result of this kind of treatment of the carbon arm, if long continued, is permanently to raise its resistance. The moral is, keep your carbon contacts perfectly clean, not sometimes, but always. No. ½ emery cloth wrapped around a small file makes an excellent cleaning tool.



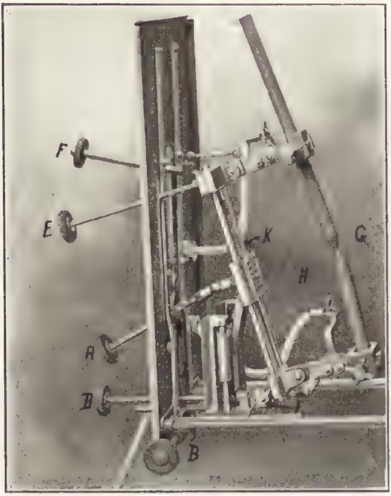
SIMPLEX

Asbestos Wire Lamp Leads. — The asbestos wire lamp leads should be attached to the carbon arm by means of a wire terminal similar to those shown in Fig. 29, Page 87. See Page 50 and Page 233 for further important matter on the subject of lamp leads.

Be sure that your lamp wire contacts are kept perfectly clean. They should be well polished at least once every week. Metal oxidizes under the action of heat, and the scale thus formed, while very thin, has high resistance. Due to this fact it is difficult to maintain good electrical contact at these connections. The scale may be almost invisible, but it is likely to be there just the same, particularly if a copper wire-terminal is used.

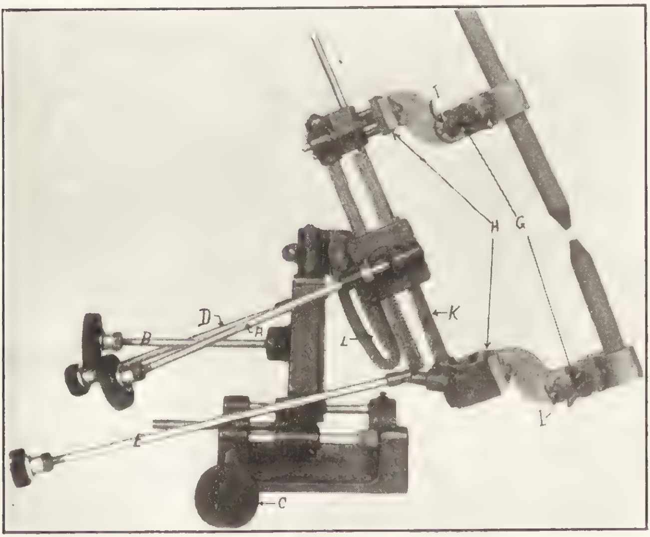


MOTIOGRAPH
Figure 114B.



AMERICAN STANDARD

Lamp Insulation.—The insulation between the carbon arms and the body of the lamp must, of course, be perfect. A ground is often formed through carbon dust settling on the lower carbon arm and forming a bridge across the insulation. This sort or ground would not carry much current, but it is likely to give the operator a good, lively shock just the same, if the lamphouse is insulated and he is grounded. If, on the other hand, the lamphouse is grounded there may be a con-



BAIRD

Figure 114C.

stant though slight loss of current. The moral is, keep the dust brushed off the top of your lower carbon arm.

The insulation of the lower carbon arm should project above the surface of the metal at least one-eighth of an inch. If it does not, loosen the joint and insert a piece of mica, allowing it to do so.

Lamp Adjustments.—The modern lamp has the following adjustments, all capable of being made by means of adjustment wheels *outside the lamphouse.* (a) The whole lamp up and down; (b) the whole lamp backward and forward; (c) the arc itself sidewise; (d) movement of rack bars to feed the arc; (e) side movement of upper or lower carbon independent of its mate; (f) movement backward or forward of the upper or lower carbon independent of its mate. These independent carbon movements, e and f, are of much importance, since only by their use can the crater properly be handled and compelled to form in the proper position. (See "Setting the Carbons," Page 290.)

The backward and forward movement of the whole lamp should be accomplished by means of a very coarse screw or its equivalent, since it is foolish to be compelled to give the adjustment wheel half a dozen turns in order to move the lamp a quarter of an inch.

Angle of the Lamp.—The angle at which the lamp should be set is varied somewhat with the kind of current and amperage. For direct current it is sufficient to say that the angle should be as much as it is possible to give without causing the lower carbon tip to interfere in the light. (See "Carbon Setting," Page 290.) With A. C. the same thing is true, but one has to use considerable more care when dealing with A. C. unless the amperage be above 60, since the crater is very small.

MOTOR DRIVEN MACHINES

The motor driven machine is a fixture. I believe it fairly may be said that from 50 to 75 per cent of the present output of the projector factories are equipped with motor drives, and at least one manufacturer equips his entire product thus.

The motor driven machine is an unquestioned blessing to the operator, though unfortunately it is a blessing which may very easily be and all too frequently is abused. The author has long since taken the position that there is only one proper place for the operator while the picture is being projected, and that is right beside his machine, with his

eyes on the screen every instant of the time. With the hand driven machine he is *compelled* to stay there, and that is the chief advantage urged for the hand drive. However, the driving of the projector by hand involves a very distinct hardship for the operator, particularly where there is only one employed. It means that for from three to eight hours, or even longer, he is compelled to turn a crank continuously, and this task is made none the easier by the knowledge that with a comparatively nominal first cost outlay and slight expense thereafter all this drudgery could be performed by a motor.

By the adoption of an ordinance requiring that the motor circuit be controlled by a switch held normally open by a spring (the Massachusetts law) and making the penalty for holding the switch closed by anything except the operator's hand punishable by revocation of the theatre license for two days for first offense and ten days for each subsequent offense, the operator may be effectively located at the projection machine, where he belongs.

There is another objection to the motor, that is, as a general proposition the speed of a motor driven projector can not or at least *will not be* regulated to suit the action in the picture as closely as it can and probably will be where a projector is hand driven. This, however, is not or at least would not be a serious objection if some scheme be devised to keep the operator at the machine, where he belongs, because with the more up to date motor driven projectors it is possible to change the speed quickly, and with a fair degree of accuracy.

There are a number of types of motor drives. Almost every machine has a speed regulating device of its own, and of course each manufacturer claims his to be the best. They are all excellent devices of their kind, and of course the particular one put out by each machine manufacturer is especially designed and adapted for use on the machine made by that manufacturer, and will probably give better satisfaction on those machines than will any other. The mechanical construction of these various drives are shown under the head of "Mechanisms."

In addition to this, however, there are a number of motor drives made by individual manufacturers for use on old style projectors or on the newer projectors which are not equipped with a regular motor drive. Two of these which are excellent, and can be recommended by the author, are the John D. Elbert Friction Speed Controller and the Preddy

Speed Controller, both of which are moderate in price and give very satisfactory service.

Elbert Speed Controller.—Fig. 115 is an illustration of the Elbert Speed Controller. The action of this device is very simple, and it readily may be applied to any make of machine; also it may be operated in conjunction with any style of either A. C. or D. C. motor. In Fig. 115, M is a cast iron disc 4½ inch diameter, rigidly attached to the same shaft carrying two-speed pulley A; G is an iron disc, or plate, between which and a smaller one on the opposite side is clamped friction material H, which impinges upon iron disc M. Wheel G is rigidly attached to shaft E, which, together with shaft K, forms a carriage which slides endwise through standards J and L, the end motion being controlled by regulating wheel C, which operates screw F, thus moving rods E and K, wheel G and pulley B endwise. The action of this is to alter the distance of wheel G from the center of wheel M, and no matter whether the motor be attached to pulley B and the projection machine to pulley A, or vice versa, any alteration of the distance of wheel G from the center of disc M will, of course, alter the speed of the projector. It will thus be seen that this adjustment in conjunction with two-speed pulley A will make possible the graduation of the speed of the projector to any desired value. The amount of friction between wheel G and disc M is controlled by spring D, and the end thrust thus set up is carried by ball bearing N. The amount of friction provided by spring N is adjustable, and should be only sufficient to prevent slippage between wheel G and disc N, since any excess would cause the motor to consume unnecessary power; also it would cause unnecessary wear on the parts. This device is compact, and is provided with nickled compression grease cups. Its price is $15, and may be shipped parcel post.

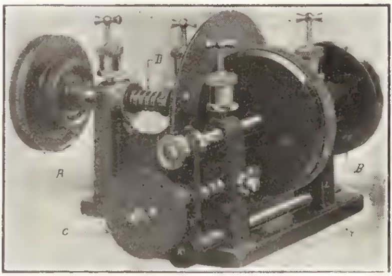


Figure 115.

Pulley B, to which the machine is presumed to be belted,

does not move endwise with shaft E, but by a very simple arrangement remains stationary, although rigidly attached to the shaft so far as the driving power be concerned. The position of pulley B and governing wheel C and screw F are interchangeable, that is to say, these parts may be made to change places, so that governing wheel C can be at either side of the device, as is most convenient to the operator. On many machines the device may be conveniently placed on a baseboard, or stand, between the lamphouse and mechanism, with the motor underneath, but the position will vary with local conditions.

Preddy Speed Controller.—Another excellent device is the Preddy Speed Controller, illustrated in Fig. 116, in which the parts of the controller are shown very plainly. It may be used with any make of projector or with any kind of A. C. or D. C. motor. Six is a disc wheel, carrying cone pulley 3, to which the projector is belted. Friction wheel 1 carries a cone pulley to which the motor is belted. Friction wheel 1 is attached rigidly to shaft 7, which is moved endwise by handle 6. This endwise movement alters the point of contact between friction wheel 1 and disc wheel 6 with relation to the center of the latter, and as will be readily seen any change in this respect will instantly alter the speed of disc wheel 6 and cone pulley 3, to which the projector is belted. This feature, taken in conjunction with cone pulley 3 and the cone pulley carried by friction wheel 1, provides a very wide and finely graduated range of speed for the projector. The amount of friction between wheel 1 and disc 6 is determined by coil spring 5, and the compression of this spring may be readily altered by moving the set collar at its end. The end thrust thus set up is carried by ball bearing 4.

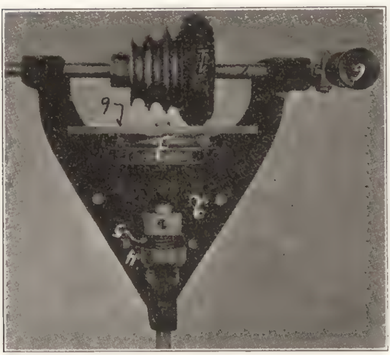


Figure 116.

In Fig. 117 the method of attachment is illustrated. It is

important that the motor be placed not less than 18 inches from a cone pulley 1, Fig. 116. The bottom lever 6 is carried by a small bolt or screw. If the lever shows a tendency to work either way of its own account tighten this bolt or screw. This controller costs $12.50. It may be shipped parcel post.

Multiple Clutch Controller.—J. Claude Re Ville, Florence, S. C., also makes a multiple clutch controller, illustrated in two forms in Fig. 118. This is a line shaft scheme by means of which one motor drives two machines. The drawings, I think, explain themselves. Either style of these clutches is claimed to be an improvement over using two motors, because of the perfect control obtained over either machine while seated at the other. These clutches are made and sold, so Brother Re Ville says, at about one-third the price of a good motor, and they are guaranteed by their makers to give satisfaction.

I do not myself think very much of the upper one, because it seems to me that either the belt would have to slip or the machine start with a jerk. The lower cone clutch, however, ought to work perfectly.

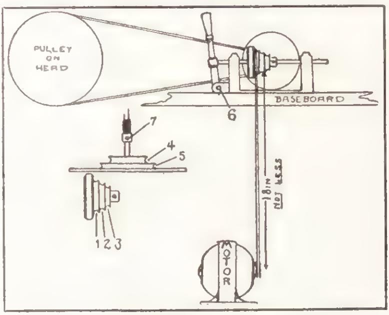


Figure 117.

A fairly good speed controller may be constructed as per the idea illustrated in Fig. 119. This device can be made efficient, but the cones must not have too steep a pitch, and the shafts must be in good alignment or the belt won't run right. In fact this cone idea is perhaps the simplest and best of any home-made speed controller I have examined. It is cheap, efficient, and fairly durable. I would, however, as a general proposition, advise operators and managers to purchase the regular motor drive attachment put out by the manufacturers of their machines.

In designing a home-made drive it should be remembered that crank speed should have a variation of about 45 to 70. *I would caution operators against belting a motor to the fly wheel of their projector.* The fly wheel of a projector is

mounted on the shaft carrying the cam. It is a high speed shaft, and in any event its bearings wear pretty fast. If in addition you add the strain of a belt the wear is increased, and wear in the cam shaft bearings has an immediate and bad effect on the intermittent movement, and, therefore, on the picture on the screen. My advice is to never under any circumstances belt your motor drive to the fly wheel of your projector. I would also advise operators and managers who build a home-made motor drive to limit the possible crank shaft speed to 70. Seventy is as fast as any projection machine ought to be run under any ordinary conditions; the

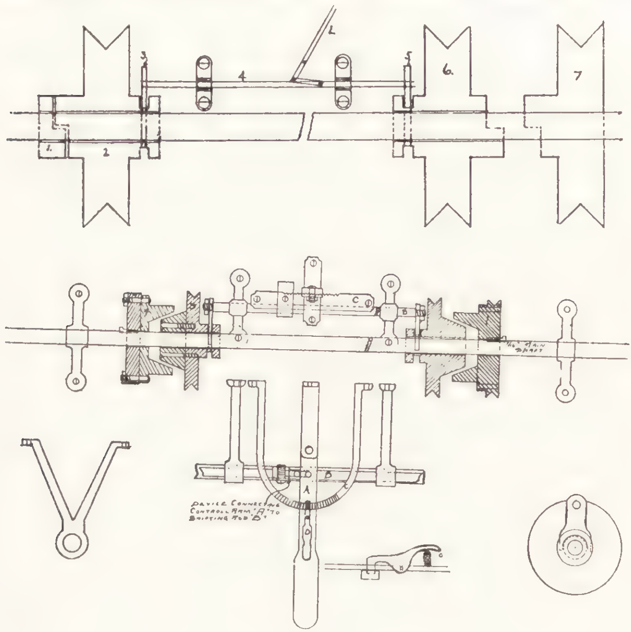


Figure 118.

limit the other way should be 45; below that the fire shutter is apt to drop.

Where motor driven machines are in use, the temptation to the operator to leave his machine, at least for short intervals of time, is strong. The manager is also inclined to have the operator utilize in rewinding, making splices, etc., what ap-

pears to him to be wasted time while the picture is running. Many otherwise good operators do this, too, but I cannot condemn the practice too strongly. I have said literally hundreds of times, and I say again, as emphatically as I know how, that WHILE THE PICTURE IS ON THE SCREEN THE OPERATOR HAS NO BUSINESS ANYWHERE ELSE UNDER THE SUN EXCEPT RIGHT THERE IN FRONT OF THE OBSERVATION PORT WATCHING THE PROJECTION, governing the speed, and regulating his light. The temptation to leave the machine is still greater if in addition to a motor drive an arc controller is used, and, in some high class houses, where high class projection is put on, I have gone into the operating room and found the operator away from his machine, and have had him stand and talk to me for as long as two or three minutes while the motor and the arc controller ran the show. The fact that there was no fault in the screen illumination during that time does not alter the fact that there *might have been,* and if there had been the operator would not have known it, and certainly he was in no position to properly regulate the speed of his projector under the varying conditions met with in different scenes of the film. I must again impress upon operators the fact that if they themselves, by their actions, convey the idea to the manager that it is not necessary to watch the picture, govern the machine speed, and be on the job every minute of the time the picture is running, the manager is very likely to become imbued with the idea that, equipped with a motor drive and an arc controller, there is no large need for high grade skill in the operator himself. This view is wrong, from any and every point of view, but nevertheless if managers get that idea operators have none but themselves to blame. I would also like to impress upon the minds of operators the fact that when the manager gets the aforesaid idea fixed in his mind it is prettly hard to convince him that there is any need of paying operators good salaries. The moral of this is: stay at your machine, watch the picture,

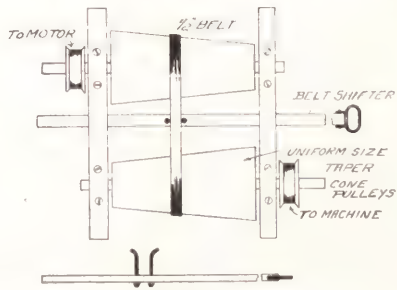


Figure 119.

graduate your speed to fit the movement in the film, and let the manager understand that, while automatic arc controllers and motor driven machines improve conditions and results, still by no manner of means do these lessen the necessity for knowledge and skill on the part of the operator himself.

WALSTAD PROJECTION STAND.—MODEL D

The Walstad Machine Company, Tacoma, Washington, constructs a very substantial, rigid stand, designed to allow the driving of two or more projection mechanisms of any standard make with one motor, the motor driving a countershaft which is equipped with separate clutches for each of the projection mechanisms, as well as a friction for driving the rewind, which is also located on the stand between the projection machines. There is also a large substantial friction, by means of which the speed of the projection mechanisms may be varied at will. One advantage of this arrangement is that the speed of both projection mechanisms is precisely the same when dissolving from one picture to the next.

All machine controls are located in such manner that the operator is enabled to handle the equipment with ease, efficiency, dependability and safety. The operator handles both machines and the rewind while standing or seated between the projectors—a very favorable feature where one operator is compelled to do the rewinding in addition to handling both projectors. I object strenuously to the operator doing the rewinding, but that is nevertheless the practice in many theatres.

In order to accomplish this the magazines of the right-hand machine are reversed (full directions for accomplishing this accompany the outfit), so that the operator threads the right-hand machine from the left-hand side. This is rather awkward at first, but he soon gets the knack of it, and he can then thread just as readily from one side as the other.

Another feature is a brake on the unwinding reel of the rewind. This brake is automatic in its action, and by its use the film is wound tightly upon the reel, which eliminates the necessity of using the hand as a brake and "pulling down," which latter operation is responsible for much of the damage to film.

The main driving shaft is mounted upon a separate frame, to which is also attached the motor, thus making the power section a complete unit within itself. This unit is attached

to the main stand by means of two brackets, as can be seen in figures 120 and 121.

The stand is substantially constructed of iron and steel throughout. It is rigid and so braced that vibration is reduced to a minimum. There is also provision for all necessary adjustments, so that the operator can readily set the apparatus to give any desired pitch in projection. The motor belt is very heavy and substantial. This stand has been in

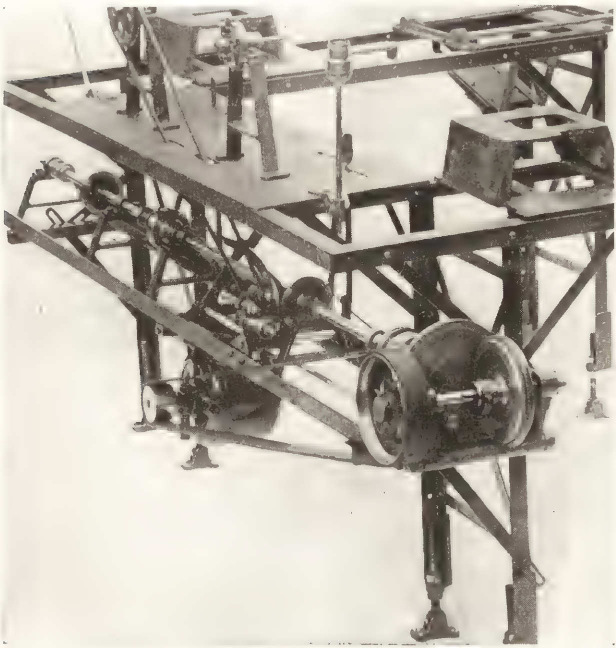


Figure 120.

use on the Pacific Coast for some years, and is no longer an experiment. Where the Walstad stand is installed, the theatre will, of course, only purchase the projection mechanisms, lamphouses and magazines.

Fig. 121 gives a very good idea of the quipment as a whole. The bases upon which are mounted the projection

mechanisms are shown at 1-1. They are made to fit any standard projection machine. Provision has been made to attach the lower magazine to the underside of the bases. In the case of the right-hand machine the upper and lower magazines are reversed, so that the doors open toward the center of the projection stand, as has already been noted; 2-2 are the bases upon which are mounted the lamphouses. These are also made to fit the various standard lamphouses; 3 is the motor which drives the complete equipment, and may be had for either A. C. or D. C. The base to which the motor is attached is so made that it will accommodate any standard motor of suitable size; 4-4 are the clutches by means of which the projection mechanisms are driven; 5 is the rewind drive; 6 is a glass inserted in the steel plate, with

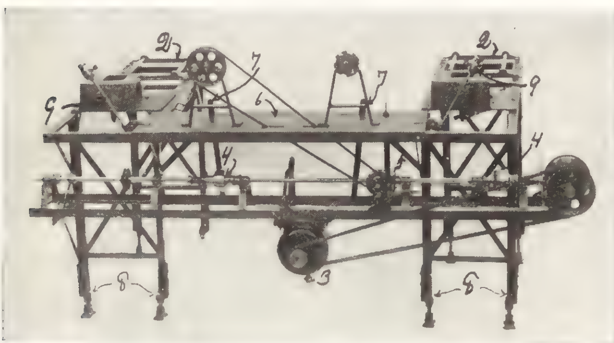


Figure 121.

a low C. P. incandescent lamp underneath for making patches and for inspection; 7-7 are the handles which control the clutches; 8-8 show the method of adjustment for pitch by means of screws, there being a similar arrangement on the rear legs. In Fig. 120 they are shown more clearly; 9-9 are lamp sockets, designed to hold incandescent lamps which swing in front of the lens during threading, for the purpose of framing; they may also be used for locating proper position of carbons after trimming the lamp.

To Operate Stand.—Place framing light in front of the objective of the left-hand mechanism. Thread film in usual way. Remove left-hand framing light. The motor having

been started, all that is necessary to start the left-hand machine is to drop the opening lever into operating position. If the speed of the machine is not satisfactory, move the control lever toward the motor to decrease speed, or away from the motor to increase it. Having got left-hand head under way at the proper speed, proceed to thread the right-hand head the same as you did the other. When the time comes to change over, all that is necessary is to drop the operating lever of the right-hand machine into operating position, after first striking your arc, of course, and when the dissolve is completed pull the lever of the left-hand machine into non-operating position.

In changing from one reel to the other no attention need be paid to the speed of the machine, unless it is desirable because of the action in the picture, since both machines will, of necessity, be running at precisely the same rate of speed. If it is desired to run the show to schedule this may be done by observing the location of the lever, according to the marks on its segment.

The author has personally examined this equipment and pronounces it first-class in every respect.

Opportunities have no schedule time! You must be at the station when they arrive.

Carbons

THE very foundation of the projection of pictures, either moving or otherwise, is light, and light for projection purposes depends, to a very great extent, upon the electrodes (carbons) with which it is produced.

Each form of arc lighting requires the use of carbons differing in material, physical characteristics and methods of manufacture. For projection work it would be utterly impracticable to use either very hard carbons or the comparatively soft, solid, impregnated flame carbons. If one attempted to use these carbons the result on the screen would be far from satisfactory.

The National Carbon Company has very kindly consented to describe for us in detail the process of carbon manufacture as follows.

Manufacture.—The manufacture of projection carbons requires more care than any other type of lighting carbons, on account of the necessity for high candle power, steadiness, reliability, color and other features. The basis of the projection carbons is lampblack, the purest form of carbon known. Even the ordinary lampblack used in the manufacture of other types of lighting carbons contains far too much ash to be used. Therefore a special, selected black is employed. Even this material contains considerable volatile matter, which is driven off by calcination at a high temperature. This calcined material is known as "carbon flour," and is so pure that it is less than one-twentieth of 1 per cent. ash, and contains little or no volatile matter. To this flour is then added a high grade binder and it is machine-mixed into a stiff mass, in a fashion very similar to that employed in kneading bread dough, after which it is made up into plugs and fed into the cylinders of hydraulic presses, which force it through suitable dies. As it comes from the presses the carbon is allowed to run on grooved boards, made for the purpose. It is now in the form of rods, approximately four feet long. Carbons which are to be cored are forced with a central hole throughout their length, made by having a steel pin fixed in the center of the hole in the die. The carbons are now ready for baking.

The form of the binder contained in the green carbon must be changed by driving off the volatile matter therein and depositing the rest throughout the electrode in the form of pure carbon. Inasmuch as the quality of the finished carbon depends on the method and temperature of the baking, this is one of the most important operations in its manufacture. The green carbons are first packed in special cylinders, to keep them from becoming crooked, and to protect them from injury, and are then placed in gasfired furnaces specially designed to secure uniform heating, from which, during the process of baking, air is excluded. The total operation of packing, baking, cooling and unpacking takes from three weeks to a month.

After removal from the furnace the carbons are cut to proper length and sorted for straightness. Owing to variation in shrinkage during the baking process, some deviation from perfect straightness must be expected. The solid and hollow carbons are now separated. The former are taken directly to the pointing machine, after which they are ready for shipment; the latter go to the coring department. Here the central hole through the carbon is filled with the core material, which is a non-flaming but arc-supporting substance. It is mixed into a thin paste with water glass, a soluble alkaline silicate, which becomes solid when dried. This core material is forced into the hole, and the carbons are then rebaked for a short time at a comparatively low temperature, in order to solidify the cores, and this operation completes the process of manufacture.

The purpose of the core is as follows: At its incandescent tip it supplies a far greater amount of arc-supporting gas than does the carbon composing the shell, and, therefore a path of lower resistance is offered between core and core, as in the A. C. arc, or between core and solid carbon tip as in the D. C. arc, than between two solid carbons. Hence the arc tends to emanate from the core, instead of wandering all over the face of the carbon. The practical effect of the core is to hold the light steady. If a solid upper carbon were used the light would jump from side to side and up and down, causing constantly recurring shadows upon the screen. It would be utterly impossible to secure a good, steady light with two solid carbons or with a solid upper carbon.

Size of Carbons.—The size of carbons is a subject approached with considerable hesitation. There is a growing tendency among operators to use three-quarter inch cored

above and five-eighth inch cored or solid below, or anything between 40 and 50 amperes D. C. This practice is approved by some of the best operators in the country—men in whose judgment I have confidence. They have tried five-eighth inch above and below, five-eighth inch above and one-half inch below, three-quarter inch cored above and below, three-quarter inch cored above and three quarter inch solid below, and have finally decided that the three-quarter inch cored above and five-eighth inch cored or solid below is best. Therefore, I recommend those sizes to operators using between 40 and 50 amperes D. C. There is considerable difference of opinion as to whether the lower carbon be solid or cored; therefore I would advise each operator to try both and decide for himself which gives best results in his case. Between 20 and 40 amperes I would advise five-eighth inch cored above and one-half inch cored or solid below for D. C. Below 20 amperes D. C. I think one-half inch cored above and three-eighth inch solid or cored below will serve the purpose very well. For A. C. on anything below 60 amperes I would recommend two five-eighth inch cored carbons above and below, and above 60 amperes, say up to 80, two three-quarter inch cored. Some operators using A. C. prefer a lower carbon of smaller diameter, so that it will needle considerably. This is a matter upon which I cannot pass, each one must experiment and decide for himself.

Solid vs. Cored Lower.—The objection to a solid lower carbon for D. C. is that it does not maintain as steady an arc as with two cored carbons. The objection to a cored lower carbon is that, while it helps maintain a steady arc, this is only true by reason of the increased volume of gas emanating from the lower core, and this forms a curtain in front of the crater, and materially diminishes the illumination.

I would not, under any circumstances, advise the use of less than 40 amperes A. C. for the projection of moving pictures. For stereopticon, however, the amperage may run as low as 25, or possibly even 20 if the picture be a small one and the screen of a semi-reflective type.

As against the above the National Carbon Company proposes the following, with reference to carbon sizes and combinations, and, inasmuch as it comes from a large carbon manufacturing company, it is certainly entitled to very serious consideration on the part of operators. It will be observed that the recommendations made by the National are pretty closely in accord with those made by the author,

and, inasmuch as each arrived at his conclusion entirely independent of the other, I feel rather flattered to know that my recommendation coincides so nearly with that of the manufacturer.

ALTERNATING CURRENT

Amperage	Upper	Lower
70-80	⅞" cored	⅞" cored
60-70	¾" cored	¾" cored
50-60	⅝" cored	⅝" cored
45-50	9/16" cored	9/16" cored

DIRECT CURRENT

Amperage	Upper	Lower
55	¾" cored	¾" cored
50	¾" cored	⅝" solid
45	⅝" cored	⅝" solid or cored
	⅝" cored	9/16" solid
40	⅝" cored	½" solid
25	9/16" cored	7/16" solid
20	½" cored	7/16" solid

Inspection.—When purchasing carbons the operator or manager should inspect them for faults. Cracks running lengthwise of the carbons do no harm. They are in a way characteristic of the product, and are caused by the stiffness of the paste from which they are formed. Deep cracks running around the circumference, however, condemn the carbons, since there would be a tendency to break off at these points. Hair cracks running around the circumference, however, are often found in good carbons; they are due to the same cause as the longitudinal cracks and are of no consequence.

Hard Spots.—There is possibly no other one thing so trying to the operator as carbons containing hard spots. When the arc strikes a hard spot in the carbon the light will jump and sputter, in spite of everything that can be done, until the spot has burned away. These spots are belived to be caused by a lack of thorough mixing in the early stages of manufacture. The manufacturers of the best carbons have practically eliminated this most serious fault.

Hard and Soft.—Carbons that are too hard have a tendency to produce a yellow light through faulty cratering and slow burning, with resultant short arc. These things naturally result in an unsteady light of low intensity. On the other hand carbons that are too soft burn away quite rapidly, but usually give a good light while they last.

Stubs.—Modern projection lamps accommodate 6 inch lower and 10 or 12 inch upper carbons. This eliminates much waste, as against two 6 inch carbons, since there is just so much "stub end" to each carbon, whether the carbon be 6

inches or 10 inches long. In other words, if you are using 6 inch carbons and are able to burn them down until there is an average of 2 inch of stub left, you will be wasting one-third of each carbon; on the other hand, if it be a 12 inch carbon the two inches of necessary waste would only be one-sixth of the carbon; therefore, the doubling of the length of the carbon cuts the waste in half.

There are, however, those who claim that the additional resistance of the long carbon is objectionable. The fact of the matter is, however, that the difference as between a 6 inch and a 12 inch carbon is too small a matter to be seriously considered, particularly in view of the fact that the resistance of a carbon decreases as its temperature increases. At any rate the constant annoyance of being obliged to reset the carbon every reel, together with the relatively large waste in carbon stubs where short carbons are used, more than balances the extra resistance loss of the long carbon. Actual experiments made by the writer show that with 50 amperes flowing through a closed circuit the insertion of 10 inches of a five-eighth inch cored carbon only reduced the current flow one ampere.

Chemicalizing the Carbon.—Many operators have experimented on a small scale in "chemicalizing" carbons, and in the opinion of the author, when it is rightly done, salt soaking has beneficial effect. Concerning this, however, the National Carbon Company has the following to say: "There is an impression current in some quarters that if the carbons are soaked in common salt brine, the harshness so frequently found in the light emanating from the A. C. arc can be softened and improved. This is a fallacy, inasmuch as the salt will almost immediately volatize out as soon as the electrodes become heated by the high current passed through them, and none of this material ever actually gets into the arc."

Now, with all due respect to the manufacturer in question, I am unable to agree with this, because what I have seen I have seen, and I certainly have witnessed an improvement in the light for which I could find no other explanation except salt soaked carbons. Untreated carbons placed in the same lamp did not produce the same effect. It is, however, only fair to manufacturers of carbons to say they spend much time and money, or at least the American manufacturers do, and I presume the foreign also, in experimenting with chemicals, in an effort to procure a product equal

if not superior to their competitors' brands at the same or lower cost. They have carried on exhaustive experiments on every point which in their estimation can have any possible influence on the operation of the arc. With their extensive laboratories and research department they have vastly better facilities for carrying on these experiments than the operator could possibly have. Therefore I would suggest that when an operator discovers something he believes will be beneficial let him communicate with the Projection Department of the *Moving Picture World,* which will lay the matter before the manufacturers.

Care of Carbons.—Carbons should invariably be kept in a dry place where they will not absorb moisture, since moisture in the carbons will be detrimental to projection light.

EQUIVALENTS

Since both lens and carbon diameter measurements are often quoted in millimeters it is advisable that the operator know what a millemeter means in fractions of an inch.

One millimeter equals .03937 of an inch, or roughly one-twenty-sixth of an inch. The equivalents from 10 to 26 are as follows:

TABLE 5.

Millemeters	Fractions of an Inch in Decimals	Roughly
10	.3937	or 4/10 inch
15	.59055	or 6/10 inch
16	.62992	
17	.66929	
18	.70866	or 7/10 inch
19	.74803	or 3/4 inch
20	.78740	
21	.82677	or 8/10 inch
22	.86614	
23	.90551	or 9/10 inch
24	.94488	
25	.98425	
26	1.02362	or 1 inch

Any millimeter measurement may be reduced to inches by multiplying by .03937. One centimeter equals .3937, or practically four-tenths of an inch. One meter equals 39.37 inches, or 3.28 feet, or 1.094 yards.

SETTING THE CARBONS

This is a subject second to none in importance. A very slight difference in the set of the carbons may make a very large difference in screen illumination, particularly when using A. C.

Practically all illumination available for use comes from what is known as the "crater." With D. C. there is only one crater, but with A. C. there are two. The crater always forms on the positive carbon. With D. C. one carbon is always positive and the other always negative, therefore the entire force of the current is expended toward the forming of a crater of ample dimension on one carbon, the positive; hence it is imperative that the positive wire be connected to the upper carbon. As has been said, the crater always forms on the positive carbon, but, remembering that with A. C. each carbon is alternately positive and negative many times each second, we readily see that a crater will be formed on both carbons, since both are positive half the time. It therefore follows that if the crater-forming force of the current is divided between two carbons, the craters will be much smaller than if an equal amperage of D. C. were used, the entire energy of which would be directed toward forming one crater.

The light giving power depends upon (a) the temperature of the crater; (b) its area; (c) the character of the carbon. The temperature of the electric arc has, so far as I know, never been actually measured. It has, however, been estimated as high as 8000 degress C. I do not know, but it is the natural inference that, since the force of A. C. is divided between two craters, and the full force directed to one crater with D. C., the temperature of the D. C. crater would be higher, assuming the amperage in each to be equal. Be this as it may, however, with equal amperage the A. C. crater is very much smaller than the D. C. crater, nor is the combined area of the crater on both upper and lower A. C. carbons equal to the area of the single D. C. crater, where equal amperage is used. See Limit of Amperage, Page 292.

Taking all these facts into consideration, it will be seen that it is very doubtful whether 40 amperes A. C. would produce a total candle power equal to that produced by 40 amperes D. C., but, laying that question aside, and even allowing the candle power would be equal, the fact still remains that it is utterly impossible to utilize nearly so great a portion of the alternating current illumination for projection purposes as can be utilized when using D. C. Referring to

Fig. 123, Page 295, and Fig. 124, Page 297, this is made clear by the examination of sketch C in both figures, which in both instances illustrates an ideal crater condition, one D. C. and one A. C. It will be observed that at B, Fig. 123, the crater is of ample dimensions, facing the lens in such manner that the strongest light hits pretty nearly the center of the condensing lens. In sketch C, Fig. 124, the crater sets at more of an angle to the lens; also it is very much smaller. The result of all this is that

While it is possible to secure just as brilliant an illumination with A. C. as with D. C. it will require practically double the amperage to do so. In other words, it will take close to 80 ampere A. C. to produce a screen illumination equal to that produced by 40 amperes D. C.

Operators will note that when the carbon tips are cold they may be brought very close together without any effect. They must, in fact, be brought into actual contact before there is any result. It will also be noted that although the carbon tips may be separated from one-quarter inch to three-eighths inch when the arc is burning normally, if the switch be opened, thus breaking the arc, and be immediately closed again, the current will leap the gap and the arc will reset itself between the still incandescent carbon points. This phenomenon is due to the fact that the carbon is volatized (transformed into a gaseous vapor) by the tremendous heat of the arc, and this vapor in itself forms an electrial conductor, though one of tolerably high resistance, while the air itself is a very poor conductor of electricity—in fact an insulator. When the carbons are cold, or only red, they are not being volatized; therefore the vapor (often referred to as the "arc stream") is not present; there is only air between the carbon tips, and air presents too great a resistance to allow the current to leap from one carbon point to the other, even when the tips are very close together. For one, two or maybe three seconds after the arc is shut off, however, the carbon still continues to be volatized, and, therefore, the vapor is present, and the space between the carbon tips still bridged by the gaseous conducting medium.

The commonly accepted explanation of the formation of the crater on the carbon tip is that minute particles are torn away from the positive carbon by the current. These particles are mostly volatized as soon as they are torn off, though some of them reach and are deposited on the negative carbon tip, only to be volatized there later. The writer

does not pretend to vouch for the correctness of this theory. It is given for what it is worth.

Limit of Amperage.—As previously stated, the larger a crater of given temperature the more light will emanate therefrom. See computing C. P. of arc, Page 293. There is, however, an economic limit to possible light gain through increased size of crater, if the light must be passed through a 4½ inch diameter projection machine condensing lens system. The theoretical light source to work in perfect accord with the optical principle involved in a lens system is a pinpoint, meaning a light the size of the point of a pin. As the area of the light source increases, the ability of the lens system to utilize the light is rapidly decreased, until a point is reached where any further gain of light through increase of area of the light source is only made at heavy expense. More than three years ago I said that this point was reached when the crater becomes one-half inch in diameter. I am still convinced that that statement is approximately correct. See "Matching the Lens System," Page 113; for further explanation and data, also see Amperage, Page 157.

This means that the economic limit of light for projection purposes lies between 50 and 60 amperes D. C., and between 80 and 100 A. C., because the 60 ampere D. C. crater will be fully one-half inch in length by almost that in width; therefore any further increase in amperage will, if my theory is correct, be of comparatively slight value.

I believe it is safe to say that beyond 60 *amperes D. C., and perhaps* 90 *A. C., not more than* 25 *per cent. of the energy expended will appear on the screen in the shape of illumination.*

A projection arc must be operated with the carbon tips a certain given distance apart, in order to obtain the best results, and this distance will vary according to the number of amperes used, the size of the carbons, etc. It follows, therefore, that, inasmuch as the carbon tips of a hand-fed projection lamp cannot be kept precisely the same distance apart constantly and under all conditions, the arc voltage will vary. Arc voltage is the pressure necessary to force the current across the space between the carbon tips.

This equals the reading of the voltmeter when it is attached to the upper and lower carbon arms when the arc is adjusted for perfect screen illumination. It is, however, the number of amperes flowing, not the voltage, which determines the size of the crater, hence the amount of light it will produce.

In this connection let us pause and consider the C. P. of the crater. It has been discovered by experiment that the brilliancy of the positive carbon crater is practically constant, regardless of amperage consumed, at approximately 158 C. P. per square millimeter where solid carbons are used, and 130 C. P. where cored carbons are used. We are not interested in solid carbons, but for cored carbons this would mean a total crater brilliancy of 130 muliplied by the square millimeter area of the crater. This figures out at 41,860 C. P. for a crater having an area of ½ square inch.

From this it will be seen that *increased amperage gives increased illumination at the rate of* 130 *C. P. for each square millimeter of additional area of crater.*

It will also be seen that, the spot being a magnified image of the crater, *it is highly important that our condenser arrangement be such that the spot be given its normal diameter without withdrawing the arc from the lens beyond the distance absolutely necessary to prevent breakage.*

By the use of the foregoing the operator will be able by estimating the area of his crater in fractions of a square inch, or in millimeters, to compute the C. P. of his projection arc with a considerable degree of accuracy.

Simon Henry Gage and Henry Phelps Gage, Cornell University, have conducted experiments with D. C. regular carbon sets which resulted as follows (See their "Optical Projection"): Using direct current and regular carbon set, as per Fig. 123, a 15 ampere, 50 volt arc, taking current through a rheostat, consuming 750 watts in the lamp and 1650 watts in total gives a total C. P. of 3490, or 4.65 C. P. per watt consumed in the arc, or 2.12 C. P. per total watt consumed in the arc and rheostat. A 40 ampere, 51 volt arc, taking current through a rheostat consumes 2040 watts in an arc or 4400 watts in total, and gives 12350 C. P., which is 6.05 C. P. per watt consumed in the arc, or 2.8 C. P. per watt consumed in both the arc and resistance.

It will be observed from this that as the amperage increases, voltage remaining essentially the same, the light giving power per watt becomes considerably greater. At 40 amperes there is a gain of 1.4 C. P. per watt of energy expended in the arc, and .68 of a C. P. per watt expended in the combined arc and rheostat, as against the 15 ampere arc.

In these experiments it was shown that a mercury arc rectifier, using 40 amperes at 52 volts, same carbon set, gave 12150 C. P., a decrease of 200 C. P. as against direct current

from a generator taken through a rheostat, which seems to indicate that the loss by reason of pulsations of the rectifier is almost negligible. With A. C., same carbon set, 40 amperes with 27 volts at the arc gave 1830 C. P., or 2.42 C. P. per watt expended in the arc, or .70 of a C. P. per watt of total energy expended in the arc and rheostat, or 2.32 C. P. per watt of total energy expended in the arc and transformer (economizer).

Experiments have proved that there is but little difference in actual cost per C. P. in light from an alternating current arc taking current through a well designed transformer (economizer) and D. C. through a rheostat, though the A. C. is much less satisfactory to use from any and every point of view.

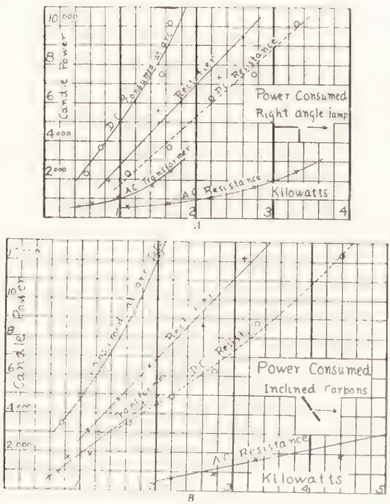


Figure 122.

"Optical Projection," by Simon Henry and Henry Phelps Gage, gives the following excellent chart of relation between power consumption and candle power. By this chart it will be seen that for the power consumed, A. C. through a rheostat gives the least per watt; D. C. through a rheostat next; A. C. through an economizer next, and A. C. through a rectifier best of all, but the chart is presumably plotted for a 110 volt supply, taking no account of a lower voltage supply. The upper left hand line shows that if only the actual power consumed in the arc itself be considered, then D. C. has much the greater efficiency. Well, I am not good at plotting curves, but if we consider a 60 or 70 volt D. C. supply, such as most isolated light plants used by theatres deliver, then D. C. through a rheostat ought to have an efficiency fully equal to the rectifier current, or possibly even of considerable greater efficiency.

This is a little digression from the main subject, which we will now resume.

Position of the Crater.—In considering light for projection, however, the foregoing must be coupled with another item of prime importance, viz., the *position* of the crater.

This latter is the most important point of all, since no matter what amount of light the arc may be producing, if that light be not directed toward the lens, then a large proportion of it or even perhaps practically all of of it will be

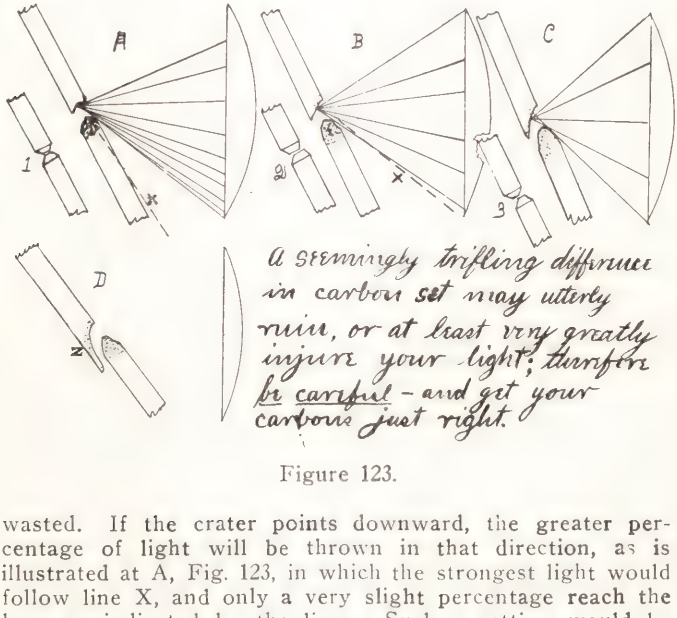


Figure 123.

wasted. If the crater points downward, the greater percentage of light will be thrown in that direction, as is illustrated at A, Fig. 123, in which the strongest light would follow line X, and only a very slight percentage reach the lens, as indicated by the lines. Such a setting would be enormously inefficient.

For best results the crater must be exactly in line with the optical axis (center) of the condensing lens. Inasmuch as all the light comes from the crater, it therefore follows that the more squarely the crater can be made to face the condensing lens, without causing the lower carbon tip to interfere too much in the light ray, the greater percentage of light will reach the lens, and be made available for projection. This is illustrated in Fig. 123, in which A shows

a highly inefficient D. C. setting; B a setting somewhat more efficient, but still not a good one because the crater points too much downward, and the strongest light would follow line X, thus missing the lens entirely. C, however, is an ideal condition—that is to say, the ideal *practical* condition, since, for certain reasons well understood by operators, it is impossible to get a good crater and have it squarely face the lens, so as to cause the strongest light to pass exactly through the center of the lens. Assuming the amperage of arcs A, B, C, Fig. 123, to be equal, each arc would give off practically the same amount of light, but that of A and B, being misdirected, would not illuminate the screen nearly so brilliantly as would the light from C.

The position of the crater is controlled by (a) the angle of the lamp and (b) the relation of the carbons to each other. The condition at A is the result of setting the carbon tips central with each other, as per 1, Fig. 123; B is the result of advancing the lower carbon tip slightly ahead (toward the lens) of the upper carbon tip, as per 2, Fig. 123; C is the result of advancing the lower carbon slightly more than at 3, as per Fig. 123. This, however, can be overdone, as is shown at D, Fig. 123. At D both the angle of the lamp and the advancement of the lower carbon is too great, the result being that, while we have a crater facing the lens squarely, still the advantage thus gained is neutralized by the fact that the lower carbon tip comes between the crater and the lens; also at Z a long skirt has formed, due to the fact that the lower carbon has been advanced too far. This form of crater is in itself inefficient, and, moreover, when the arc is shut off and the carbon is allowed to cool the skirt is apt to break off about midway of the crater, thus utterly ruining the crater and very seriously injuring the illumination until a new one is formed.

Re-examining C, Fig. 123, we observe that the lower carbon tip begins to interfere in the light at the fourth line down, but that the lower line from the lens to the crater misses the carbon tips and strikes the crater above its center. This is about as good a condition as you can hope to obtain. These sketches are not designed to accurately portray actual arc conditions exactly as they are, but merely to set forth, in understandable form, the various equations which enter into the matter of carbon setting, the faults which must be studied and guarded against, and to illustrate the best obtainable condition, which the operator should strive to attain.

When we consider the alternating current arc, however, we encounter an entirely and a radically different proposition; also one which is more difficult to handle where less than 70 amperes are used. As already explained, the crater will form on *both* carbon tips when A. C. is used, since each carbon is alternately positive and negative many times each second. As has already been set forth, the amount of available projection light will, within certain limits, be in direct proportion to the area of the crater, how squarely it can be made to face the condenser, and kind of current. With the crater-producing force divided between two carbons, as is the case with A. C., it follows that neither crater will be as large, for a given number of amperes, as would be

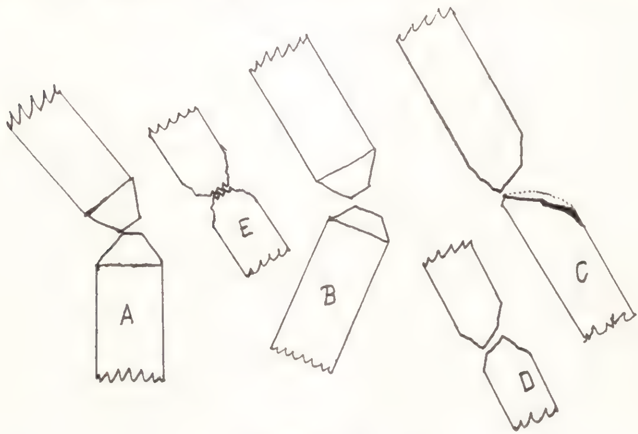


Figure 124.

the case with D. C., with which the whole crater making force is centered on one carbon. It is even true, as I have already said, that both A. C. craters combined will not equal the area of one D. C. crater, where equal amperage is used.

It has long since been very generally accepted as a fact, however, that, due to optical difficulties, *it is neither feasible nor good practice for operators projecting with A. C. to use both craters. Operators who study the details of projection have long since come to the conclusion that a more uniformly excellent result will be had by using only one A. C. crater, the upper, of course.* One effect which almost certainly follows an attempt to use both craters is a double spot at the aperture,

with liability to produce a dark, or multicolored streak across the center of the screen. This is due to the fact that the spot is merely an image of the crater (see Page 130), and with two craters there will be two images, which are not superimposed upon each other.

For years an effort was made to use both craters by means of what was known as the "jackknife" set, illustrated at B, Fig. 124, and A, Fig. 124. Some also attempted to utilize both craters by setting the lamp straight up and down, but these schemes have, for the most part, been relegated to the scrap heap, where they rightly belong, and today the b st men, men securing the best results and holding the best positions, almost invariably use practically exactly the same set (illustrated at C, Fig. 123, and in Fig. 126), both for A. C. and D. C., or else use a very modified jackknife set by setting the lower carbon so that it angles out very moderately with relation to the rackbars, angling the top carbon to meet it, as in A, Fig. 124. Even this scheme has, however, been largely discarded in favor of the regular D. C. set. Years ago I advised, both in my books and in the Projection Department of the *Moving Picture World*, the use of the same set for A. C. and D. C. *I still advise it*. Theoretically, setting the lamp straight up and down is better; *practically*, however, *it is not*. By using the straight up and down lamp set, or the jackknife set, one is enabled to get considerably higher candle power through the lens for a given amperage. That is a conceded fact, but the fly in that particular box of ointment is that *a steady light absolutely cannot be maintained with these sets, or,* in other words, the curtain illumination cannot he held at uniform brilliancy. I cannot recommend either the setting of the lamp and carbons perpendicularly, the jackknife set, or any other set except that shown in Fig. 126, Page 300, known as the "regular D. C. set."

At E, Fig. 124, we see the result of carrying an alternating current arc too short—the carbons too close together. The A. C. arc is very short—much shorter than the D. C., and this fault must be carefully guarded against. The D. C. current arc of 40 amperes will be one-quarter inch to three-eighth inch in length; the A. C. arc of less than 60 amperes will not be much in excess of one-eighth inch. It is thus made plain that the operator has slight leeway in handling the A. C. arc. It must be watched very carefully, fed frequently, and not allowed to vary from normal length. The condition shown at C, Fig. 124, is as good as you can hope for when using 60 amperes or less. It can only be obtained

by very careful adjustment of the carbons, and maintained by exercising watchful care. D shows a condition where the lower carbon tip has been advanced a little too much with relation to the upper one, so that the front edge of the lower crater is built up until it shuts off a large portion of the light emanating from the upper crater. This condition, too, must be carefully guarded against. The only remedy for condition E, Fig. 124, is to burn a long arc until the saw teeth are burned off. The only remedy for condition D, Fig. 124, is to alter the relation of the carbons by shoving the top carbon tip ahead slightly, or pulling the lower one back.

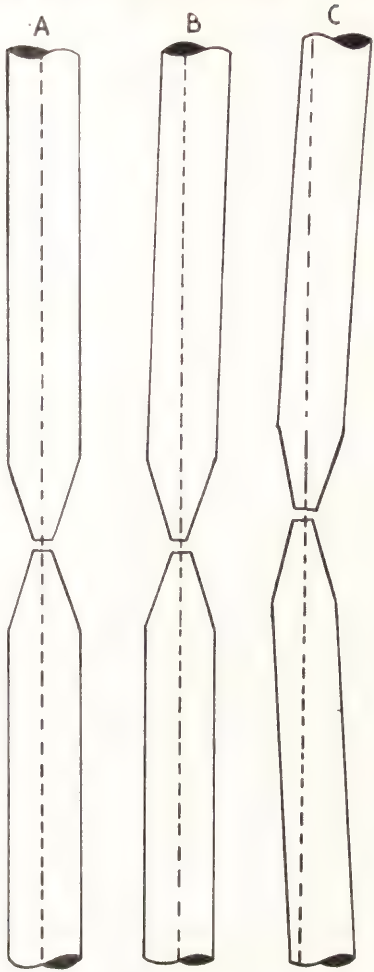


Figure 125.

When using D. C. the careless operator who allows his arc to become too short may find the tip of his lower carbon crowned with a sort of mushroom—a cap having a slim stem. This cap is composed of graphite. It is caused by keeping the carbons too close together, so that the arc does not get sufficient air properly to volatize the carbon. Under these conditions the carbon particles carried from the crater are deposited on the top of the negative carbon in the form of graphite. Graphite has high resistance, and will withstand enormous

temperature for a long time. Therefore, this cap or mushroom is consumed very slowly. The remedy is to knock it off with a screw-driver having an insulated handle, and to be careful not to again allow the arc to get so short.

Side-Lining the Carbons.—It is essential that the upper and lower carbons set exactly straight with each other, viewed from the front—that is to say, through the condensing lens opening, as per A, Fig. 125, in which A shows correct lining; B, top carbon out of line and C both out of line.

Modern lamps have an adjustment by which the carbon tips may be lined with each other sidewise, but if the upper and lower carbons be not in line with each other throughout their length then as they burn away a constant sidewise adjustment of the carbons will be necessary to keep the crater from moving over to one side.

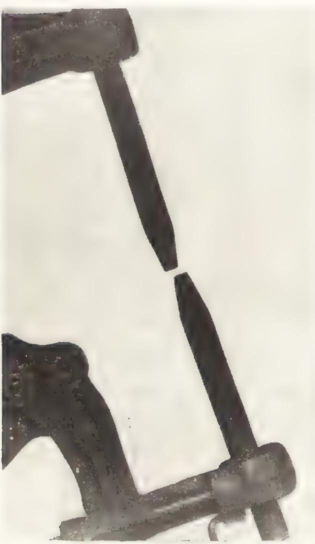


Figure 126.

When the operator takes charge of a plant, or when a new outfit is purchased, he should put in two carbons of equal diameter, line their tips exactly sidewise and then, with a straight edge laid against the side of the two carbons, test them for side line. If either carbon is out of perpendicular he should carefully file the carbon clamp until the matter is remedied. It is no uncommon thing to find lamps with either the upper or lower carbon, or perhaps both, out of plumb sidewise. With some lamps it is possible to remedy this matter by loosening the screws which hold the carbon arm and shifting the arm slightly.

At Fig. 126 is a photographic representation of the set which I strongly recommend for both D. C. and A. C.

In closing the subject of carbons let me impress upon your minds as strongly as possible the following:

Only the best possible results from a given amperage can be had when the crater is in precisely the right position with relation to the lenses, with the least possible interference by the lower carbon tip, and this condition can only be obtained by a very careful adjustment and setting of your carbons.

Some interesting data and information may be found in the following tabulated results of experiments made by the editor.

SET: FIVE-EIGHTH INCH CORED ABOVE AND BELOW.

Current Through G. E. 50 Ampere Mercury Arc Rectifier on Lowest Notch.

Approximate distance between carbon tips at their nearest point.	Voltage at Arc.	Amperage.
1/16"	40	33
1/16"	45	28
3/32"	50	25½
1/8 "	55	22½
3/16"	60	20
1/4 " Arc unstable.	65	16½
5/16" Arc very unstable.	70	15
	75 Arc went out.	

SET: FIVE-EIGHTH INCH CORED ABOVE AND THE SAME SIZE SOLID BELOW.

Approximate distance between carbon tips at their nearest point.	Voltage at Arc.	Amperage.
1/32"	40	31
3/32"	45	27½
3/16"	50	24½
1/4 "	55	22½
5/16"	60	18½
3/8 " 7/16"	65	11½
	70 Arc very unstable and went out after five seconds.	

It was observed that with two new five-eighth inch cored carbons, in order to keep the arc voltage down to 50, and thus keep the amperage within reasonable bounds, it was necessary to separate the carbons 1¼ inches for the first 15 to 30 seconds, after which the arc resistance gradually but rapidly rose, until a 50 volt, 25 ampere arc was had with as little as three-thirty-second inch separation at the nearest

point of contact between the lower tip and the crater on the upper carbon.

With a new set of the same size carbons, but with cored above and solid below, the extreme distance was reduced from 1¼ inch to 1 inch, and the arc voltage reduced to normal much earlier than with two cored.

After striking an arc with two new five-eighth inch cored, burning it 20 seconds, breaking it long enough to measure distance between tips, and relighting, with 30 volts across the arc there was still 50 amperes, and the arc was still abnormally long. Under similar conditions, with two cored and the arc voltage at 40, amperage stood at only 30.

All this has some value in that it shows a less tendency to heavy current rush on new sets when a solid is used below.

Carbon Economizers.—There are now on the market a number of good carbon economizers, ranging in price from 50 cents to $1 which may be had from supply dealers. These devices are designed to allow the operator to consume his carbon stubs down to the shortest possible length. Some are made of brass, and some of iron. They are simple and quite effective.

Lighting Interior of Lamphouse.—It would be a very simple matter to place a small porcelain lamp receptacle in the bottom of the lamphouse, at the right hand, front corner. From one side run a wire to one side of any convenient incandescent circuit. From the other side attach to the other side of the circuit through a spring-switch, made as per Fig. 127, attached to the right hand lamphouse wall in such way that a piece of fibre fastened to the lamphouse door will shove the switch open, thus putting out the light, when the lamphouse door is closed.

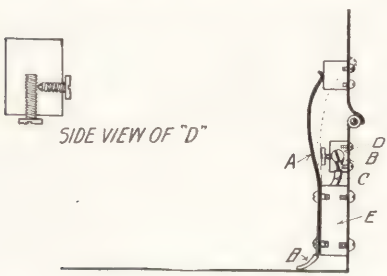


Figure 127.

By the use of a low C. P. lamp the interior of the lamphouse is thus automatically illuminated when one opens the door to re-set the carbons, etc.

Arc Controller

WHILE the Arc Controller is a new invention it has been in use long enough to thoroughly prove its practicability and utility; also it carries with it the indorsement of the Projection Department of the *Moving Picture World.*

The function of the controller is automatically to feed the carbons of the arc lamp. Its method of accomplishing this is quite simple and thoroughly positive.

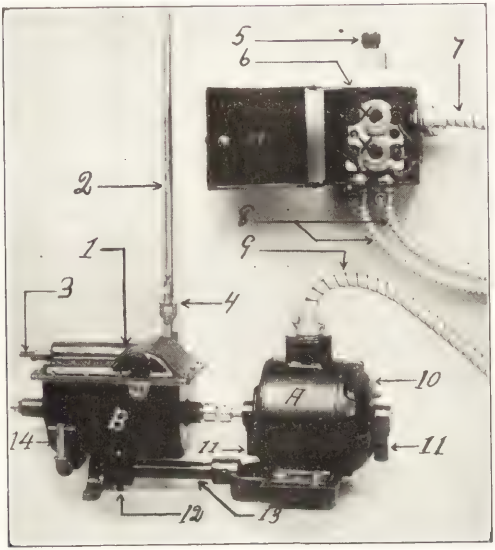


Plate 1, Figure 128.

Broadly speaking, the amperage of the arc is regulated by the voltage of the arc, and no matter whether current be taken through a rheostat, directly from a generator, or through a transformer, *any change in voltage across the arc will cause corresponding change in amperage at the arc.* If the voltage rises the amperage drops; if the voltage drops, the amperage rises. This is what may be termed the immutable law of the electric arc.

The Arc Controller operates as follows: In P. 1, A is a small motor which drives the mechanism of controller B, illustrated in P. 3. Controller B, P. 1, is connected to the arc lamp by means of rod 2, P. 1 and 2, this rod being driven by gear 44, P. 3. By tracing through the connection you will see that motor A is thus positively and directly connected to rod 1, P. 2, which is commonly known as the "feed handle" of the arc lamp—the handle by means of which the carbons are fed together. Motor A, P. 1, is connected to the line by means of wires contained in cable 9, P. 1, the other end of which is seen at 7, P. 1, where it joins the fuse box. The motor is not connected directly to the supply line, but to the projection machine table switch contacts, through cables 8, P. 1, which are controlled by switch 5, P. 1. It will thus be seen that motor A does not receive the full line voltage, but only the arc voltage, which varies with the length of the arc. Now, even the novice will understand that *the speed of motor A will depend upon the voltage of the current with which it is supplied, hence, any rise in arc voltage, no matter how small, will increase the motor's speed.*

Referring to P. 2, knurled knob 12 passes through fibre disc 9, through the end of brass lever 16, and impinges on the surface of fibre disc 8.

Brass lever 16 is hinged to a steel collar, which passes over and is attached to feed rod 1, P. 2. Now, when knurled knob 12 is backed off (unscrewed somewhat), it has the effect of unlocking fibre disc 8 and driving gear 4, from fibre disc 9 and feed rod 1. In other words, when knob 12 is loosened, or backed off, the lamp becomes a plain hand-fed lamp, of which fibre disc wheel 9 is the feeding knob or wheel, and the motor is allowed to drive gear 4 and fibre disc 8, without moving rod 1, P. 2. Conversely, when knurled knob 12 is screwed in the whole thing is locked together, and the motor then drives lamp feed rod 1, P. 2, direct, by means of gear 6 acting on gear 4, thus feeding the carbons of the lamp together. To make matters still more clear, gear 4 and fibre disc 8 merely use rod 1 as an axle. They are entirely independent of disc 9 and rod 1, except when locked to them by knurled knob 12. When not so locked, gear 4 and disc 8 can rotate without in any way affecting disc 9 and rod 1. The operation of the device is as follows: When the operator is ready to strike his arc, he closes switch 5, P. 1, which starts motor A running, but it is only driving fibre disc 8 and gear 4, P. 2. The operator now strikes his arc by means

of the hand feed (disc 9, P. 2), in the usual way, adjusts it at approximately the right length, and then screws in knurled knob 12, which locks the mechanism together, and thereafter he theoretically need give the arc no further attention whatever.

You will observe I said "theoretically"; this by reason of

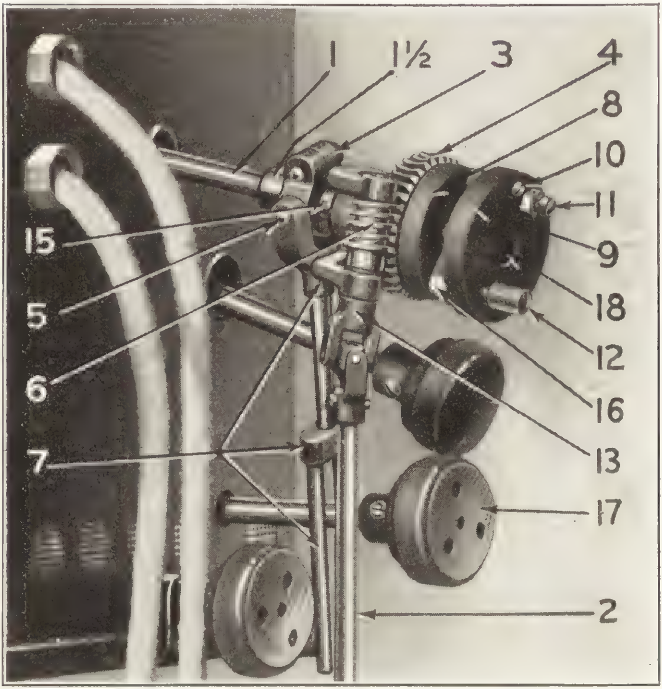


Plate 2, Figure 129.

the fact that faults in the carbon and things of the sort may make it necessary occasionally to work the hand feed. As a general proposition, however, the controller takes care of the entire situation, so far as feeding of the carbons be concerned, and I have myself seen a full show of eight reels run without the operator at any time touching the arc lamp, ex-

cept to strike and set the arc at the beginning of each reel. The controller maintains a perfectly steady arc voltage, hence a perfectly steady arc amperage and even light density.

The Controller.—P. 3 is an interior view of controller B, P. 1, with cap 1, P. 1, removed. In this view gear 10 is the gear which meshes with gear 44, P. 3, which drives rod 2, P. 1. Now follow me closely: Spring 41, P. 3, is attached to pawl 23 by slipping bend 42 into the eyehole at 22 of part 23, P. 3.

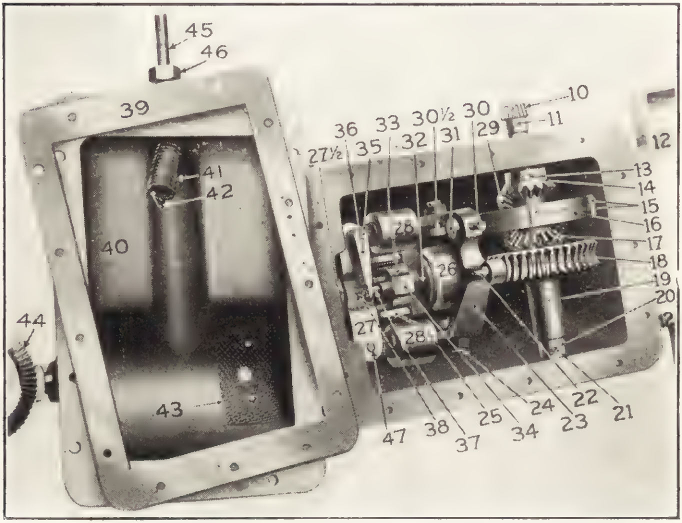


Plate 3, Figure 130.

This has the effect, when cover 40 is in place, of holding part 23 back, in the direction of the arrow point 34. Parts 28-28 are governor weights attached to governor cross bar 27 by means of hinge pin 47 and 35, and right here is what might be termed the heart of the whole machine. Part 33 swivels upon part 32 and the whole governor is attached to the main driving shaft by pin 38 in part 27. Part 31 is a steel tooth driven through part 23, and protruding about one-eighth inch on the side next to wheel 16. All the parts between part 27½, which is a ball bearing, and part 26, an-

other ball bearing, which includes the entire governor, revolve at the speed of the motor, and weights 28-28 are held normally in, by means of spring 41 which holds part 23 back against ball bearing 26, which in turn presses back part 32, carrying pins 25, which bear on the inner end of the arm carrying weights 28-28. Before going any further study this action closely, and get it firmly fixed in your mind.

Now here is how the thing operates. The motor runs constantly, but its speed increases as the length of the arc increases, because the voltage increases with length of arc, and as a result of the increased motor speed, governor weights 28-28 are thrown outward against the pull of spring 41, which has the effect of forcing part 32, ball bearing 26 and part 23 ahead, thus engaging tooth 31 with one of stop teeth 15 on wheel 16.

Gears 14-17-29 form a "differential," gear 29 being attached to wheel 16, gear 14 to shaft 19 (by means of pin 13), and gear 17 to gear 18. Underneath gear 18 is a worm gear attached to the shaft connecting the controller to the motor—the main driving shaft. This worm gear drives worm gear 18, mounted and riding loosely on shaft 19. When the motor is running, but the arc is not being fed, the motor continues to drive gear 18, but, wheel 16 being free to turn, the differential acts and gear 29 simply runs around on gear 13, without operating gear 10. A moment's study will, I think, enable you to understand this action. It is very similar to the action of the differential of an automoble. Gear 29 must rotate gear 10, which in turn drives gear 44 and rod 2, P. 1 and 2, and through it lamp feed handle 1, P. 2, thus feeding the lamp carbons together, shortening the arc and reducing the voltage so that the motor slows up, whereupon spring 41 overcomes the lessened centrifugal force acting on weights 28-28, so that they are pulled inward, which disengages tooth 31 from tooth 15, which causes the differential to act and the carbons are no longer fed.

The speed necessary to cause tooth 31 to engage tooth 15 will depend entirely upon the tension of spring 41, which is regulated by nut 46 on bolt 45, P. 3, (3, P. 1), and this tension must be adjusted by the operator as soon as he has the controller connected up, as will be hereinafter explained.

Oil.—The well formed by the gear casing should be kept filled with a good grade of dynamo oil. Oil is poured in through oil well 14, P. 1, *and it should reach the level of the top of the spout.* One filling of good lubricant ought to last about

500 running hours. Before refilling, remove the plug in the opposite end of 14, P. 1, drain out all the old oil, replace the plug, fill the well with kerosene and let the machine run for a few minutes; drain the kerosene out and then refill with clean oil.

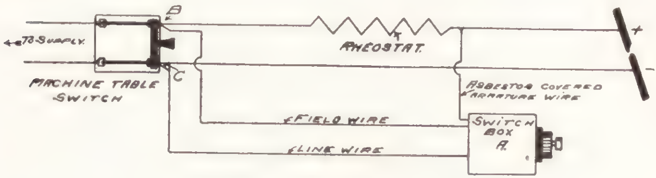


Plate 4, Figure 131.

Caution:—You are cautioned against the use of the very thin, much *advertised oils. They are totally unfit for use on such machines as this.* The manufacturers of the controller recommend Solar Red Oil. I do not personally know anything about this lubricant, but presume it is good. In any event, however, a good grade of dynamo oil will serve the purpose. If the Solar Red Oil can be had, use it; if not, use the other, which you can no doubt obtain from your local electric light company, or from any reliable oil dealer.

Connecting the Machine.—When a controller is received and unpacked, *examine the packing carefully, making sure that no small parts are thrown away.* Also remember that the manufacturer will not recognize claims for shortage unless made immediately after receipt of the machine. The apparatus will consist of the following: (a) The controller and motor, connected in one unit, as shown in the lower half of P. 1, including cables 7, 8, 9 and the fuse box as shown in P. 1. All this will be found coupled together when received: (b) telescope rod 2, P. 1 and 2, consisting of a steel rod inside a brass tube; (c) collar 1½, part 3, including gear 6, fork 7 and universal joints 13, P. 2; (d) gear 4, fibre knobs 8 and 9 and part 16.

After unpacking and inspecting the parts proceed as follows: First set the controller and motor, B-A, P. 1, on the floor immediately under the feed rod handle of the arc lamp. It may be set on a block high enough to raise it out of the dirt—say 3 to 6 inches, if desired. If necessary the controller may be set a little to one side, or a little back, if the conduit carrying the lamp leads is in the way. Within the limits

of the reach of telescopic rod 2-2, P. 1 and 2, the position of the controller may be changed The idea is shown in P. 7.

Caution:—In this connection be very careful not to get the controller so far away from a position underneath the lamp feed handle that universal joint 4, P. 1, and the universal joint 13, P. 2, will be at too great an angle and bind. It is hardly probable that you would do this, but it is nevertheless possible, and must be guarded against.

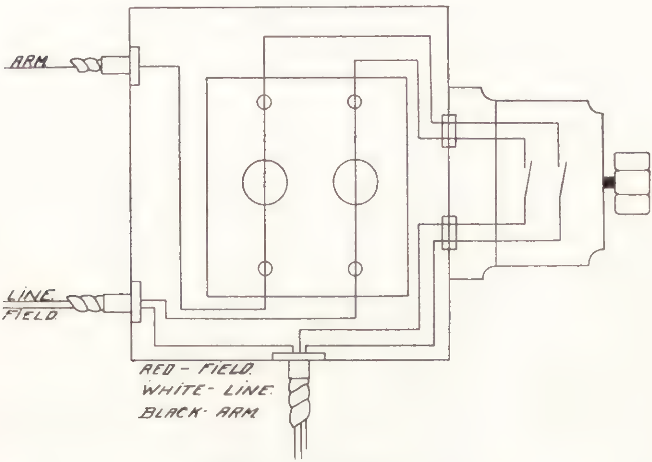


Plate 5, Figure 132.

Having placed the controller, next take off the feed wheel, or knob, from the rod which feeds the carbons of your lamp, and slip collar 1½, P. 2, on the rod. Now, take part 3, carrying gear 6 and fork 7, in your left hand, and gear 4 and fibre knobs 8 and 9 in your right hand, and fit them together so that gear 6 meshes properly with gear 4, and the hole through the hollow stem, 18, P. 2, is clear, except for the pin passing through it. Having fitted the parts together in your hand, slip the whole on rod 1, first having removed knob 17, P. 2, or the knob of some other rod which comes most directly under rod 1, and make fork 7 straddle the rod; after which knob 17 should be replaced. It may not be necessary to remove knob 17. Very likely you can get the fork over the rod without. The reason for fork 7 straddling one of these rods is to prevent part 3 from turning—to hold it stationary.

Slip these parts on rod 1 until its end strikes the pin which you will see in hole 18, about one-half inch from the surface of the fibre knob. This pin must not be removed. If the parts do not go on the rod easily do not try to force them but find out what is wrong and remedy it. Having accomplished this, tighten up set screw 15, P. 2, good and tight. Bring back collar 1½ to about the thickness of a postal card from the sleeve inside part 3, and tighten its set screw.

Now all you have to do is to connect rod 2, P. 1 and 2, with universal joints 4, P. 1, and 13, P. 2, and remove the wooden plug from the cover of the controller. Its use is to preserve

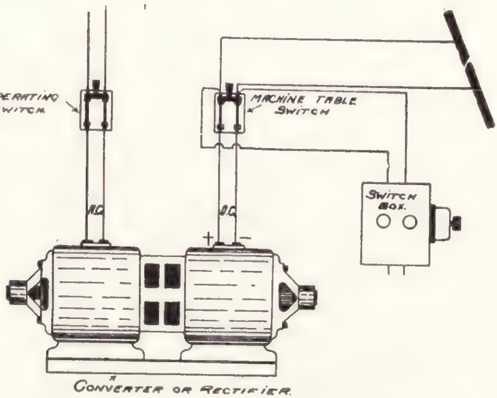


Plate 6, Figure 133.

in transit the oil with which the controller is filled. The hole that it protected is a "breather," and must be left open when the controller is in operation.

If gear 6, P. 2, does not incline at the proper angle to clear rod 2 from any obstruction, loosen a screw on the right side of part 3 and, with knurled knob 12 loosened, turn gears 6 and 4 and fibre knob 8 to the desired angle. Then tighten the screw in part 3 very tightly. This completes the mechanical installation.

Electrical Connections.—First if your current is D. C. see to it that your rheostat is placed in the *positive* wire (the wire leading to the upper carbon), and between the machine table (operating) switch and the lamp. *If it is on the negative wire change it to the positive,* and then if the current is 110 or

115 volts make your connections as per P. 4, in which A is the switch-box, shown photographically in P. 1, and diagrammatically in P. 5. On the leads from switch-box A will be found tags reading respectively "field," "line," "armature," the field and line wires being in the same B-X conduit. The field wire must be connected to the positive pole of the machine table or operating switch, *on its dead side*, at B, P. 4. The

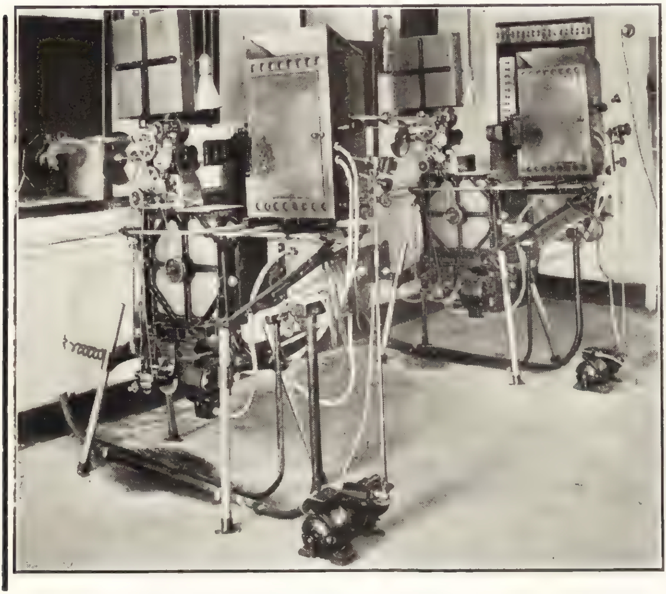


Plate 7, Figure 134.

line wire must be connected to the opposite pole, at C, P. 4. The armature wire, which is asbestos covered, must be connected to the positive asbestos covered lamp lead (one leading to upper carbon), between the rheostat and lamp, as per P. 4. This may be done by removing the insulation of the lamp lead for an inch or so, scraping the wire strands and the end of the armature wire perfectly clean, wrapping the end of the armature wire tightly around the lamp lead and soldering the joint, after which the joint must be wrapped with insulating tape. *It is* VERY IMPORTANT *that all the electrical connections be perfectly tight.*

P. 5 shows the wiring of switch-box A, P. 4, and 6, P. 1. The B-X conduit joining the switch-box and the motor A, P. 1, contains three No. 14 wires, each having a different colored insulation, one red, one white and one black. The red is the field wire which connects through the switch-box, to B, P. 4; the white wire is the line which connects at C, P. 4, and the black the armature. which emerges from the switch-box as an asbestos covered wire. The connections are perfectly plain when you, in your mind, substitute P. 5 for switch-box A, P. 4.

Caution.—*Be very sure that your rheostat is located on the* POSITIVE *wire and* BETWEEN THE MACHINE TABLE OR OPERATING SWITCH AND THE LAMP. If it is on the other (line side) of the machine table switch, change it, since otherwise the controller would not work.

It is, however, possible to have the rheostat in the negative wire or on the other side of the operating switch by using different wiring diagrams, and the manufacturers provide for this if notified, but the simplest way is to use one diagram and change the position of your rheostat if necessary.

When using converted alternating current, through a motor generator set, rotary converter, or mercury arc rectifier, or where D. C. voltage is reduced by D. C. to D. C. economizer, the wiring diagram as per P. 6 must be used, though it applies to no other condition.

In ordering the controller you should send an exact diagram of your wiring, decribe, in detail, the various apparatus used, and give the kind of current and its voltage, and, if A. C., the cycle. In using diagram, P. 6, if there is an arrangement for switching over to A. C. in case of failure of converting apparatus, *then the controller connections must be on the converter side of a double-throw switch which will cut it out of service when A. C. is used, because under no circumstances must the controller be subjected to alternating current, or any voltage higher than* 115.

Operation.—The controller will maintain the length of arc for which it is adjusted, and the length of the arc is altered by tightening or loosening nut 46, P. 3. After the controller has been connected up and put into operation, if the arc is too short, tighten up on this nut; if it is too long loosen it until the desired length is attached. Examine the oil cups of the motor once a week and fill them up. Examine the commutator of the motor occasionally.

Should anything go wrong with the internal gearing of the controller it will be necessary that it be returned to the factory for adjustment. It is not advisable to try to repair the controller yourself, but, on the other hand, it is extremely improbable that anything will go wrong.

Use only motor brushes supplied by the manufacturers. The motor brushes may be removed by unscrewing their brass retaining disc, but in replacing be sure they are exactly in the position from which they were withdrawn. The manufacturers show one pencil mark on the *top* of the left-hand brush and two pencil marks on the *top* of the right-hand brush to indicate their correct positions. The box in the top of the motor is merely a junction box in which the leads from the motor are soldered to those in the B-X leading therefrom.

ASBESTOS COVERED LAMP LEADS

The connection between the machine table switch and the arc lamp and between the machine table switch and the rheostat invariably is made with what is called asbestos-covered strand wire, this by reason of the fact it must be quite flexible; also, its insulation must withstand considerable heat.

Following the recommendations of the Projection Department of the *Moving Picture World* and the Handbook the general practice is to use No. 6 asbestos wire, and this size is ample for ordinary work. However, everything considered, I believe that in houses where high amperage is used it would be good practice, and true economy in the end, to use No. 5 instead of No. 6 abestos wire. No. 6 is more than capable of carrying the current, it is true, but portions of it are subjected to pretty high temperature, so that, on the whole, while granting that No. 6 will answer, I believe No. 5 would be still better.

Before asbestos strand wire is purchased a sample, which may be only half an inch long, should first be secured and the diameter of a few of the strands, picked out at random, carefully measured in thousandths of an inch, with a micrometer caliper. Having done this you can look at Table 6 and see what number of wire the strands are. Next multiply the diameter by itself, which will give you the C. M. cross-section; count the number of strands in the wire, and multiply the area of one strand by the total number of strands, which will give you the total C. M. cross-section

of the sample. Compare this with area of the wire it is supposed to be and if there is a discrepancy on the wrong side don't buy the wire, but demand one having such number of strands that their combined cross-section will equal the cross-section of this size wire you want. This is important, because many manufacturers of stranded wire, depending upon the carelessness or ignorance of the purchaser, hold out from five to ten strands. Only a vigorous, combined kick will stop this practice.

Operators should watch their asbestos wire closely, and as soon as that portion inside the lamphouse begins to feel "soft" and pliable, without any spring to it, the end should be cut off and thrown away, since it has high resistance, and in a day's run will waste more power than it is worth. See Page 233 for a suggestion on this latter.

TABLE 6.

Diameter of Small Wires.

B. & S. Gauge.	Diameter in Decimal Fractions of an Inch.	Diameter in Mills.
21	.028462	28.
22	.025347	25.
23	.022571	22.5
24	.020100	20.
25	.017900	18.
26	.015940	16.
27	.014195	14.
28	.012641	12.5
29	.011257	11.25
30	.010025	10.
31	.008928	9.
32	.007950	8.
33	.007080	7.
34	.006305	6.
35	.005615	5.6

Note: Mill diameter is not exact.

Toledo Non-Rewind

THE Toledo non-rewind includes an aluminum cast magazine, 5 inches deep by approximately 16 inches in diameter, upon the back of which is mounted an intermittently running motor which drives a mechanism carrying reel A, plate 1. This reel is specially designed. Its hub is collapsible, being controlled by lever 1 and spring 2. Mounted

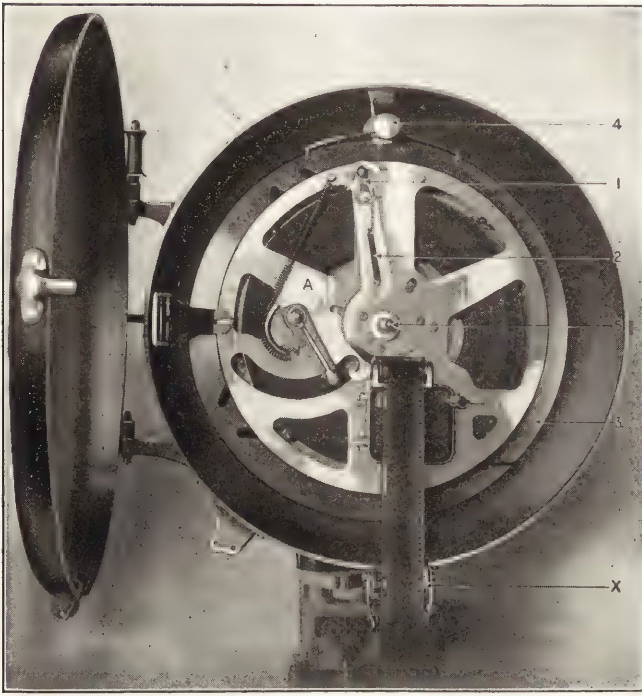


Plate 1, Figure 135.

on a circular metal plate 3, to which the reel is attached when in the magazine, is a collapsible metal band, not visible in the photograph but controlled by knob 4, P. 1. The operation is essentially as follows:

When the reel is received from the exchange it is placed in the magazine on an extension to spindle 5, and the mag-

azine is, by a suitable mechanism, shown at X in P. 2, released and swung half way around, whereupon the film may be threaded through the magazine the same as it would be were the regular upper magazine in use, a non-rewind reel meanwhile having been placed in the lower magazine to receive the film. After the film is wound on the non-rewind

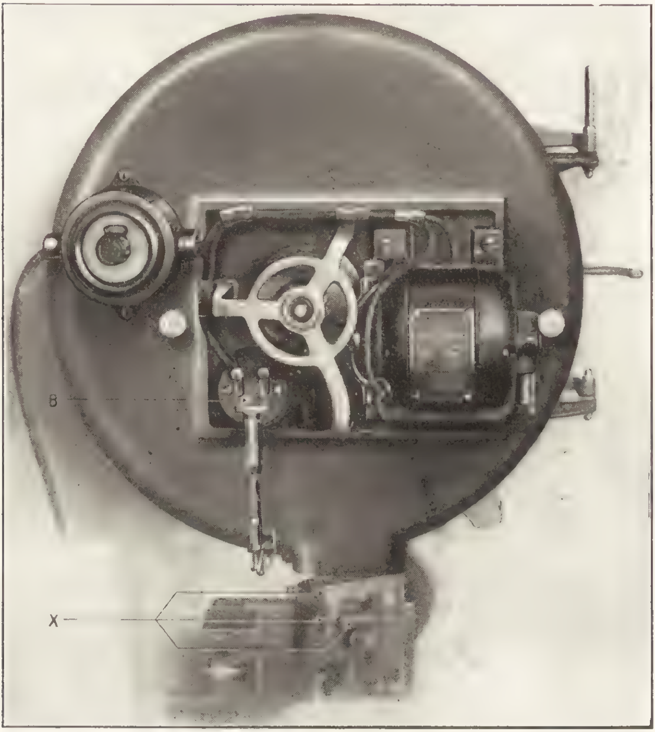


Plate 2, Figure 136.

reel the operation from then on is simple. The non-rewind reel is placed in the upper magazine, and the mechanism is, by a few simple moves, adjusted, locking the reel to the back plate which is driven by the motor on the back of the magazine, P. 2. After locking the reel into place, the collapsible band is, by the movement of a lever, brought down

until it clamps the outer circumference of the film. This band expands and contracts in a true circle, and will accommodate a reel of film as small as 450 feet or as large as 1100 feet.

It is somewhat difficult to describe the action of this machine without an abundance of carefully numbered photographs, which, as the Toledo was only placed on the market at about the time this book was ready for publication, there

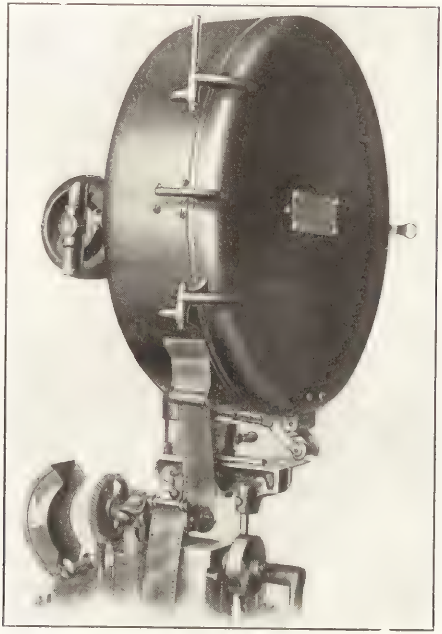


Plate 3, Figure 137.

was not time to prepare. However, the motor shown in P. 2 is controlled by switch B, P. 2, and this switch in turn is actuated by a roller which bears upon the film at X, P. 1. When the length of film shown in P. 1 is drawn taut this roller is shoved back, which raises switch B, P. 2, thus making electrical contact and starting the motor. When the motor is running, the reel in the upper magazine is revolved, which has the effect of releasing a portion of the film and literally shoving it out of the reel. The instant this is done, the

length of film shown in plate 1 slacks, which lets the roller go forward, thus opening switch B, P. 2. As a matter of fact, in actual operation the motor starts and stops about twice every second.

As will be seen the film is taken from the center of the reel. It is brought out across an angle piece and comes down through a firetrap, into the mechanism, through which it is threaded in the usual way. The power required, so far as wattage be concerned, is almost nothing. It would probably not add more than 25 cents to the current bill in a whole month, if it does that much.

P. 1 and 2 show the front and back views, and P. 3 the magazine turned to receive the exchange reel on the first run. With this device it is not necessary to do any rewinding at all.

Feaster Non-Rewind Machine

THIS device is a highly practical mechanism by means of which the rewinding of film is eliminated, except that it is necessary for the operator in the first place

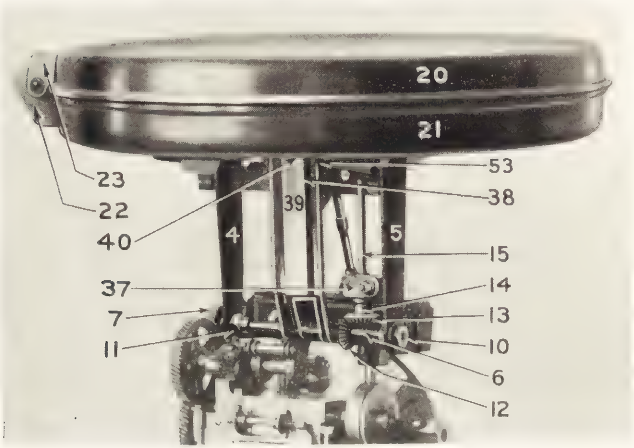


Plate 1, Figure 138.

to wind the film from the exchange reel to a special reel, which is a part of this outfit. It can be attached to any machine by the average operator in just a few minutes.

The magazines, 20-21, Plate 1, set level, regardless of the angle at which the projector mechanism may set. There are few parts to wear out, and any film in condition to go

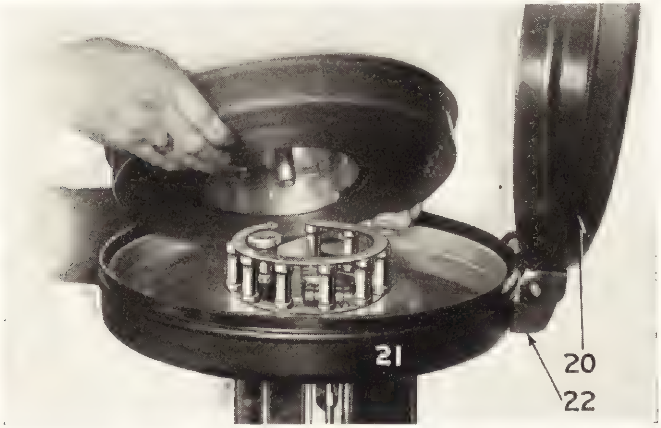


Plate 2, Figure 139.

through a projector will successfully pass through the Feaster. In P. 1 and 2 the device is seen attached to a Power's mechanism. It attaches with equal facility to any standard projection machine.

In attaching the Feaster to a Power's machine all that is necessary is to remove the upper magazine and replace it with the Feaster, adjusting it with thumb screws provided until gear 7, P. 1, meshes properly with the gear on the projector. Whereupon tighten up thumb screws, 3, P. 2, and level the magazines by means of turn-buckle 16, P. 2. This whole operation should not consume more than five minutes. Attachment to other makes of machine is almost equally simple. The added complication in threading amounts to very little.

Plate 2 shows the method of placing the film in the magazine. The film is first rewound from the exchange reel to a special Fenston reel, enough of which are furnished to carry any show. One side of the reel is instantly

detachable. The threading is quite simple and sprocket, 41, P. 3, maintains a constant supply of film to the mechanism, between which and sprocket 41, inside the magazine,

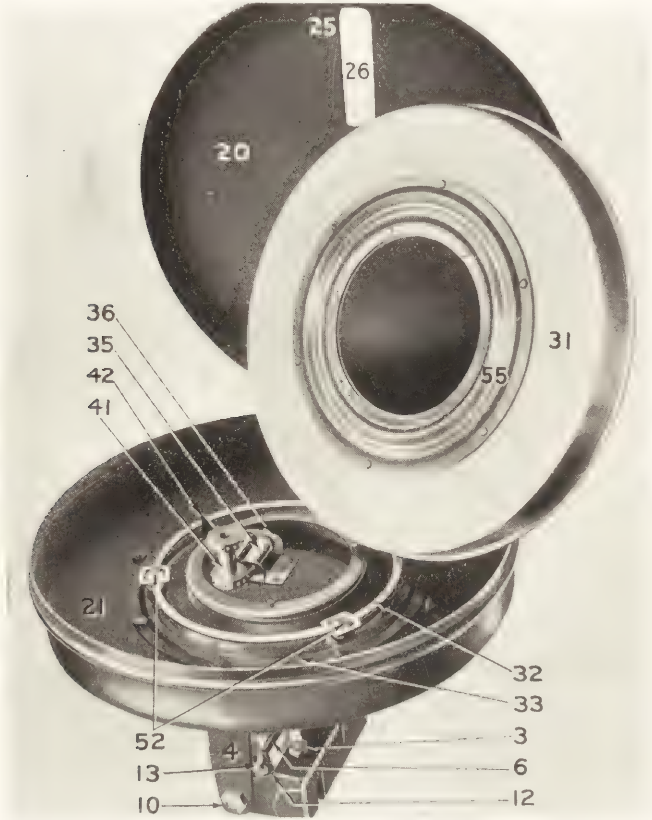


Plate 3, Figure 140.

there is a loop as per P. 4. P. 4 shows the internal construction. Pan 31, which carries the film roll, rides on steel balls (three of them), 52, which are held equidistant from each other by ring 32. The friction is thus reduced to a negligible quantity.

This or similar machines are to be commended for several reasons, not the least of which is that in many houses where the operator has been required to do the rewinding, he will be given just that much additional time to attend to his projection, and thus the show will be benefited. The

Plate 4, Figure 141.

most important reason for recommending these machines, however, is that their general use will very largely decrease the damage done to film.

Resistance as Applied to the Projection Circuit

RESISTANCE as applied to the projection circuit is no different in principle from resistance applied to any other circuit, but it will, nevertheless, I think, be advisable to give somewhat extended explanation of various points, since the element of variable resistance enters very largely into the matter.

As a rule the voltage of the supply is a fixed quantity, which may be anything from 60 volts to, in extreme cases, 500, but ordinarily is either 60, 70, 110, or 220.

The requisite amperage is an extremely variable quantity, ranging from as low as 12 for stereopticon projection to, in extreme cases, as high as 80, or even 90 in the projection of moving pictures. As a general proposition, however, amperage requirement for moving picture projection will range from 25 to 50 D. C., and from 40 to 60 A. C., though much more than 60 amperes A. C. ought ordinarially to be used.

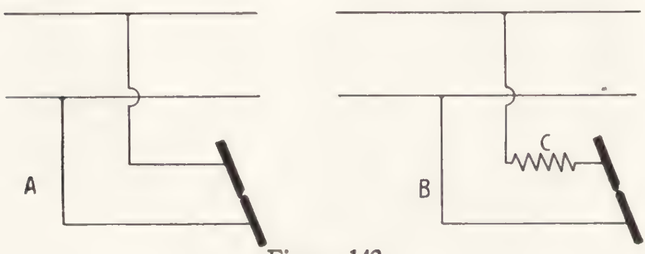


Figure 142.

Now with a fixed voltage, 100 for example, the amperage will depend upon the resistance encountered. Having first carefully read and considered the text matter under "Resistance," Page 34, let us examine the resistance of the projection circuit, laying aside, however, the resistance of the line and carbons, which is, in itself, a small quantity, usually ignored when figuring projection circuit resistance.

If we were to connect a projection lamp to the supply lines as indicated at A, Fig. 142, when the carbons were brought together a dead short circuit would be established, which would instantly blow a fuse. To avoid this we establish resistance in the form of a "rehostat," as at C, sketch B, Fig. 142. This resistance operates precisely the same as does the resistance in the filament of an incandescent lamp. It only allows a certain given amperage to pass, the amperage being dependent upon the voltage and the number of ohms resistance contained in resistance C.

But right here another equation enters. The foregoing is true only so long as the carbons remain in contact with each other. The instant they are separated an arc is struck, and additional resistance is established in the arc itself, the amount of which will vary somewhat with the amperage, but more largely with the distance the carbons are separated from each other. However, in picture projection it is found that, with a given amperage, there is one certain distance at which the carbons must be separated from each other in order to secure the best possible projection light, and this distance cannot be allowed to vary appreciably without injuring the illumination of the screen, nor does the resistance vary to any large extent with ordinary differences in amperage. Therefore the resistance of the D. C. arc, when it is handled properly, will only vary between 45 and 55 volts, seldom exceeding the latter quantity when operating at its best, and that of the A. C. arc of ordinary amperage, say up to 60, between 30 and 38.

In the second edition of my Handbook I selected 48 as the figure fairly representing the voltage of the average D. C. projection arc. I see no reason to change that figure; therefore we will continue to consider the projection arc as having a voltage of 48, with the qualification that this is subject to variation between 45 and 55. In the same book I selected 33 as representing the average voltage of the A. C. arc. I think, however, in that case 35 is probably more nearly representative than 33, therefore I will now change my estimate of the average voltage of the A. C. arc from 33 to 35, and consider it as having a voltage of 35 in the future, understanding, however, as with the D. C. arc, it is a variable quantity, 35 being designed to represent the *average*.

Now, having fixed all this clearly in our minds, let us proceed a little further. The supply voltage is, as has been said, fixed, meaning that each theatre is supplied with cur-

rent at a certain given pressure, say 110 volts. One theatre may, however, require 35 amperes D. C. and another 45. How is each requirement to be met, when both have a 110 volt supply?

The answer is simple. Merely by varying the amount of resistance in rheostat C, sketch B, Fig. 142. It is also possible that only 12 or 15 amperes may be required at the stereopticon lamp, which simply calls for additional resistance in rheostat C, sketch B, Fig. 142.

It is not only possible, but it is common practice so to arrange resistance that the amperage may instantly be varied at the arc merely by moving the lever of a dial switch. This is accomplished by what is known as an adjustable rheostat, the principle of which is illustrated in Fig. 143, in which A-B are supply lines, the rheostat in this

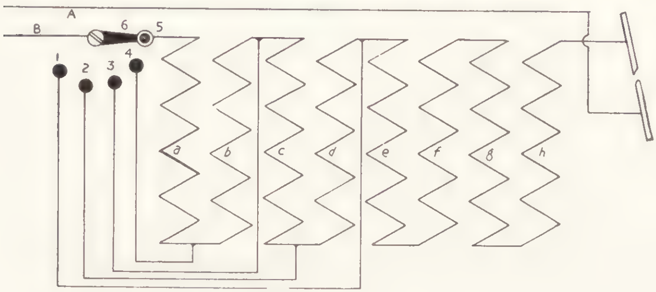


Figure 143.

instance being connected into line B. Line B connects to lever 6, which is the arm or lever of the dial switch, 1, 2, 3, 4 and 5 being its contacts. With the lever on contact 5, as shown in Fig. 143, it will be readily seen that the current must pass through the entire eight coils of the rheostat, therefore with the lever on contact 5 the rheostat is supplying all the resistance it is capable of. If, however, we move the lever to contact 4, it will be seen that the current will pass down the wire and enter the resistance at the bottom of coil a, thus eliminating that coil, and, of course, its resistance, which increases the amperage accordingly. On the other hand, if lever 6 be on contact 3 then the resistance of two coils will be eliminated; if it be on contact 2, three coils will be eliminated, and if on contact 1, four coils will be put out of business, and we will then only have the

resistance of coils e, f, g, and h, which forms what is known as the "fixed resistance" of an adjustable rheostat.

The fixed resistance of the adjustable rheostat must always be sufficient to prevent enough current passing to overload the wires or grids composing the fixed resistance.

This, I think, ought to make the action of the adjustable rheostat fairly clear. The same thing is seen photographically illustrated on Page 338, Figs. 151 and 152.

Other rheostats called "fixed resistance" rheostats have no dial switch. Their resistance cannot be varied without removing the casing and making a special connection. Still other rheostats are built of cells, each cell being a complete rheostat, containing a fixed amount of resistance. Each one of these cells may be combined with the other cells, either in series or multiple, as will be hereinafter explaind, so that the operator may vary the amperage by changing the connections.

In considering Fig. 143, if all the variable resistance is "cut out," leaving only the fixed resistance to oppose the voltage, and the coils or grids in the fixed resistance become red hot, then either the rheostat is not well designed, or else it is being used on current of higher voltage than it was intended for. A rheostat will do the work even though its coils or grids get red hot, but if worked under these conditions the life of its coils or grids will be very greatly shortened, and the heat may at any time become such that the metal will be burned in two (fused), thus stopping all current flow.

It is a very good plan to have a few extra rheostat coils, or grids on hand, so that repairs may be made by the operator in case a coil or grid burn in two. Making such repairs is a comparatively simple operation, requiring only a fund of good judgment and horse sense, remembering always that *it is absolutely essential that all coils or grids be thoroughly insulated from the frame and casing.*

Remember that, no matter what the form of your rheostat may be, whether round, rectangular or square, whether of fixed or variable resistance, whether of coils or iron grids, its electrical action is always exactly the same. The current enters at one end of a series of coils or grids, passes through each coil or grid and loses a portion of its voltage in the process of overcoming the resistance.

One point puzzles many very good operators, viz.: the voltage of the arc varies comparatively but little, and if it

be true that the voltage is reduced according to the amount of resistance in the rheostat, why is not the arc voltage varied more greatly when a portion of that resistance is cut in or cut out of the rheostat?

This is by reason of the fact that the increased or decreased flow of current through eliminating a portion of the resistance, or adding resistance, automatically takes care of the matter, though it is true, as has been said, there is some fluctuation in the arc voltage when the amperage is changed. The whole question of resistance as applied to the projection arc is complicated. Results depend upon so many different things that it is quite difficult to arrive at a complete and clear understanding of the thing as a whole. We know how it works and what will be the result of the various things we may do, but it is sometimes rather difficult to enter into detailed explanation of the exact why and wherefore of these results.

Always thoroughly insulate your rheostats, either by placing on asbestos, slate, marble, or some other heat-resisting insulating material. It is always possible that one of the coils of a wire coil rheostat will sag and touch the casing. If the rheostat itself be thoroughly insulated from the ground no immediate harm will be done, always provided no other coil does the same thing, but if this happens and the rheostat be grounded there is likely to be a blown fuse.

It is also possible that a coil may sag against the casing, but not form sufficient contact to allow of anything more than slow current leakage. This may not cause the fuses to blow, but will nevertheless cause constant loss of power, and that loss will be registered on the meter. I have known of instances where managers have complained of excessive current bills, only to finally discover it was due wholly and entirely to this kind of leakage, Not enough current flowed to cause excessive heating, or to affect the fuses, therefore the operator had no suspicion of the existence of the fault.

Never place rheostats on an iron covered shelf, or on other current-carrying material likely to produce a ground should the casing or frame of the rheostat become charged with current. Always place them on insulating material.

Temporary Rheostat Repairs.—If a coil of the rheostat should burn out and you have no other coil at hand, temporary repairs may be made as per Fig. 137, in which the dotted line represents the defective coil, and the black line

a No. 6 copper wire, doubled, which has the effect of eliminating one coil. This kind of repair will work all right until a new coil can be procured and installed. You may also procure soft iron, from any hardware store, size No 8 (diameter .128 of an inch), and make a temporary coil which may be installed in place of the defective one; such a coil will work all right for a time. The wire may be wound into a coil by using a mandrill of proper size set in a lathe, or you may wind it by using a piece of ⅜ or ½ inch gas pipe, or even a broom handle. Attach one end of the wire to the pipe, or whatever you use for a mandrill, and the other to some fixed object, backing away the length of the wire and rolling the mandrill while you pull on it, thus rolling the wire on the mandrill in a close spiral, which must be stretched

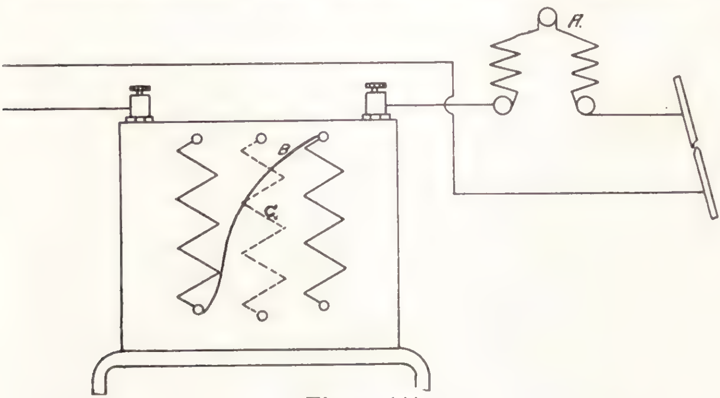


Figure 144.

slightly endwise when installing, so that the spirals will not touch one another. There must be not less than 1/16 and preferably 1/8 inch between each spiral when the coil is installed. In installing a coil be very certain it is thoroughly and completely insulated from the frame of the rheostat.

Locating the Rheostat.—Under no circumstances should a rheostat be placed within less than one foot of any wall containing inflammable material, unless there be a sheet of ⅜ inch asbestos between it and the wall, with at least a 1 inch air space between the asbestos and wall.

Rheostats in any case get very warm, and when working to capacity reach as high as 500 to 600 degrees Centigrade; when

overloaded the coils or grids may even become red hot, therefore they MUST *be thoroughly protected, not only from direct contact with, but from close proximity to anything inflammable.*

It is exceedingly difficult to give advice as to the best location for rheostats. Much depends on local conditions, and whether or not the operator wishes to vary his amperage while running the pictures. If he does not wish to do this I would strongly advise that the rheostats be located outside the operating room, this by reason of the fact that they are in effect an electrical stove, and in summer the operating room is plenty hot enough without unnecessary heating apparatus. Then, too, when located in the operating room there is always the danger of film coming into accidental contact with them, with resultant call for the fire department.

If in the operating room they should be located on a shelf near the ceiling, and as close as possible to the vent flue. If they cannot be located near the vent flue, then over them should be a metal hood connecting with a metal pipe (ordinary stove pipe with riveted joints will do) which should extend through to the open air, or, better still, connect with a chimney flue, the idea being to cause the large amount of heat generated by the rheostat to be carried off into the open air.

If the operator has adjustable rheostats and desires to vary his amperage frequently it is quite possible to locate them at any desired point inside the operating room and by the use of levers control the dial switch from operating position at the projector.

Fan Blowing on Rheostat.—In one instance, at least, I know of an operator locating his 45 ampere rheostat in front of a window, with a 12 inch fan something like 2 feet from its side, the rheostat casing being removed. This rheostat supplied 45 amperes constantly to two projectors 11 hours a day. You could lay your hands on the grids at any time. It looked like a very good scheme.

Examining Wire Connections.—It is absolutely essential that the wire connections to the rheostat be frequently and carefully examined. Copper oxidizes under the action of heat, and if left too long a thin scale of oxidized metal is likely to form on the wire, the lug, or both. This scale will be very thin, and practically invisible, but nevertheless it has very high resistance. My advice is to take your rheostat contacts loose once every week and clean them thoroughly

with emery cloth, or by scraping, particularly if the rheostats are working at or near their capacity.

If your rheostat is delivering too much current when all the resistance is in, or if it gets too hot, you may reduce the current to any desired amount by mounting extra rheostat coils or coils made of No. 8 soft iron wire on porcelain insulators, as at A, Fig. 144, Page 327. Ordinary porcelain or "knob" insulators will do, but behind the coils must be placed a thickness of ¼ inch sheet asbestos, or millboard, with a 1-inch air space between it and the wall, and over them you should place a wire screen, having about a ¼ inch mesh to protect them from accidental contact from film or other inflammable substance.

Iron Wire Rheostats.—It is quite possible to construct a rheostat from ordinary iron wire, but such wire has a very high temperature coefficient, which means that its resistance increases rapidly with the increase of temperature. The result of this is that if you build an iron-wire rheostat to give you the amperage you want after it has become hot, it will give altogether too much when you first strike the arc.

Amount of Heat Permissible.—The heat in rheostat coils or grids should in no circumstances exceed 900 degrees Fahrenheit. This temperature will make rheostat coils visible in a dark room, a dull red heat being approximately 1300 Fahrenheit and a cherry red 1500. As a matter of fact this is too high a temperature for true economy. Five hundred degrees Fahrenheit is probaply, all things considered, as high as your rheostat ought to reach in temperature. This would mean that the casing containing the coils would probably not reach a temperature in excess of 200 degrees Fahrenheit, which would eliminate all danger of fire. The life of your rheostat will be greatly prolonged if it does not exceed 500 degrees Fahrenheit, and will be correspondingly shortened if it does exceed that temperature. You may reduce the temperature of your rheostats by increasing their resistance (thus reducing the amperage) as per Fig. 144, adding another rheostat in multiple to bring the amperage up to what it was. As a matter of fact if managers would install two rheostats working at half capacity, instead of one at full capacity, the general results would be better and the rheostats last almost forever.

Two forms of resistance are employed in rheostats, viz., wire coils and cast-iron grids. The cast-iron grid is, however, in effect, nothing more or less than a wire made of

cast iron, and everything said of one applies to the other. A grid rheostat has certain advantages, also certain disadvantages, as set below.

Disadvantages.

(a) More difficult to replace broken grids than coils.
(b) Heavier than coil rheostat.
(c) Grids can be broken by heavy jar.
(d) Temperature co-efficient less fixed, therefore, somewhat less reliable.

Advantages.

(a) Better able to withstand overload and high temperatures without damage.
(b) Grids less likely to sag and become grounded to the casing than coils.
(c) Grids give longer service than coils and deteriorate very slowly.

Series and Multiple Connections.—Many of the younger operators are vastly puzzled by that really simple proposition, "series," and "multiple" connection as applied to rheostats.

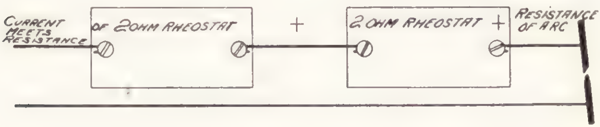


Figure 145.

The series connection is very clearly illustrated in Fig. 145, in which the voltage is opposed by the resistance contained in the two two-ohm rheostats, plus the resistance of the arc itself, *the whole acting as one unit,* making a total of four ohms plus the resistance of the arc, which latter would be its voltage divided by the number of amperes flowing. This constitutes a "series" connection. The term series, as applied in this connection, meaning one after the other, or, in practice, the connecting of two rheostats in such manner that their total resistance will be opposed, *as one unit,* to the voltage.

At B, Fig. 142, we see another example of series connection, in that resistance (rheostat) C is placed in series with the resistance of the arc, so that the resistance of both act as a unit. When we connect a rheostat into a projection circuit we term it placing resistance "in series with the arc," meaning that the voltage will meet the opposition of the combined resistance of both the rheostat and the arc.

The multiple connection is equally simple, though to the novice extremely puzzling.

In Fig. 146 we see a water main, A, carrying water, say at 110 pounds pressure. Below is pipe B, which supplies a large water motor, the same being connected to A by pipes

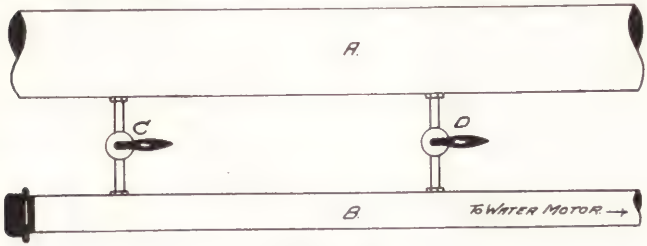


Figure 146.

controlled by stop-cocks C and D. Now it will readily be seen that with valve C opened and valve D closed only the capacity of the pipe controlled by valve C will reach pipe B and the motor, whereas, if both valves C and D are open the capacity of both pipes will enter pipe B.

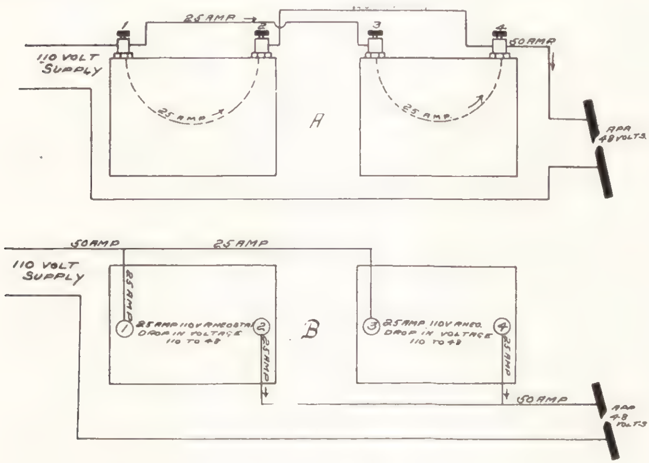


Figure 147.

Now, turning to Fig. 147, exactly the same proposition applies electrically; at B the upper wire, connecting to binding posts 1 and 3, represents water pipe A, Fig. 146, the

lower wire, connecting to binding posts 2 and 4, and the arc lamp represents pipe B, the arc itself represents the water motor, and the resistance in each rheostat represents a pipe and valve corresponding to C and D, Fig. 146. The action of the water in Fig. 146 and the action of current in Fig. 147 would be identical. Each rheostat is a 25 ampere, 110 volt instrument, meaning that it has just enough resistance to allow 25 amperes to flow when connected in series with a 48 volt arc, and opposed to 110 volts pressure. Under the conditions shown in Fig. 147, 25 amperes will flow from the upper wire through binding post 1 and the resistance of the rheostat to binding post 2, and thence to the arc; 25 amperes will also flow from binding post 3 through the resistance of the second rheostat to binding post 4, and thence to the arc, joining the 25 amperes coming from the first rheostat, and thus 50 amperes will be delivered at the arc.

The idea is perhaps a little more clearly shown at A, Fig. 147, in which the dotted line is used to represent the passage of the current through the resistance of the rheostat from binding post 1 and 2 and 3 and 4. A and B, Fig. 147, are identical, except that B is a diagrammatic top view, whereas A is a side view showing the wires about as they would appear in practice. The multiple connection is shown photographically in Fig. 148, Page 335.

Any number of rheostats of different voltage may be connected in series, provided the total resistance of the whole be sufficient to reduce the current flow to a point where the resistance will not be overloaded.

Any number of rheostats, each having sufficient resistance to oppose the line voltage without overload, may be connected in multiple, regardless of their amperage capacity. For instance, a 25 ampere, a 12 ampere and a 50 ampere 110 volt rheostat could be connected in multiple on 110 volts, and the result would be current delivery equal to their combined capacity, or 87 amperes.

You can use a 220 volt rheostat on 110 volts, or, for that matter, on 60 volts, but you would only get amperes equal to 220 minus the arc voltage divided by the resistance of the rheostat. The resistance of such a rheostat would be $(220 - 48) \div$ by its rated amperage on 220 volts. You cannot, however, connect 110 volt rheostats, either singly or in multiple, on 220 volts, since there is not resistance sufficient to withstand that pressure. The coils would quickly become overheated and would soon burn out. You may, however,

connect two 110 volt rheostats *in series* on 220 volt current (though they would be slightly overloaded), by reason of the fact that you would be, in effect, making one rheostat out of the two, and would thus present double the resistance required for 110 volts.

You may use a rheostat built for certain voltage on that pressure, or anything less than that pressure, but you cannot use a rheostat on a higher pressure than it was intended for, except it be placed in series with additional resistance.

This, however, may be qualified to the extent that a rheostat built for a certain voltage may usually be used on current five, ten, or even fifteen volts in excess of that pressure.

A. C. and D. C. Rheostats.—There is no such thing as a "D. C." or an "A. C." rheostat. *Any rheostat will work on either A. C. or D. C.,* but a rheostat that will deliver 30 amperes when working with a D. C. projection arc, on, say, 110 volts pressure, will deliver considerably more on the same voltage A. C., by reason of the fact that the A. C. projection arc is shorter, hence offers less resistance, so that the total resistance opposed to the current is reduced.

This, however, is again qualified by the fact that there is a tendency to induction when a wire-coil rheostat is used on A. C., which has the effect of adding inductive resistance, or, in other words, magnetic kick. The amount of inductive resistance thus set up will vary with the size of the coils, their length and the closeness of the spirals. It amounts to something, but not very much. The inductive effect, however, causes vibration in the coils, and as a result some wire-coil rheostats are very noisy when used on A. C. This noise may be reduced by packing the center of the wire coils tightly with shredded asbestos forced in at the end of each coil.

The use of rheostats on A. C. is very, very bad practice. It is unnecessarily wasteful. Where alternating current is used rheostats should be replaced by low voltage transformers. See Page 343, or, better still, with a mercury arc rectifier or motor generator set, see index.

If, however, for any reason it is necessary to use resistance in A. C. projection circuits I would advise the grid type, since they are likely to be a great deal less noisy; also there is much less inductive effect; therefore the resistance will be found to be more stable.

Rheostats Extremely Wasteful.—The real use of the rheostat in the projection circuit is to consume the differ-

ence between the line voltage and the arc voltage, or, in other words, to break the line voltage down to the value of the arc voltage. This represents an absolute waste of energy, since the difference between the line voltage and the arc voltage is, and must be, dissipated in the form of utterly useless heat generated by the rheostat, and this wasted energy is all registered on the meter and must be paid for by the theatre.

Suppose, for example, the current supply be 110 volts, and that we use 40 amperes at the arc. Voltage times amperes equals watts, therefore $110 \times 40 = 4400$ watts registered by the meter. The average voltage of a D. C. projection arc is only 48, therefore there must be consumed in the rheostat $110 - 48 = 62$ volts, which will be registered on the meter as $62 \times 40 = 2480$ watts, this amount being absolute waste. We are using a total of 4400 watts, and only actually employing $4400 - 2480 = 1920$ watts in the production of light. At this voltage and amperage the rheostat is 43½ per cent. efficient.

This is bad enough, but if the voltage be higher, say 220, then the proportion of waste becomes literally enormous. Using 40 amperes from 220 volt lines through a rheostat would mean $220 \times 40 = 8800$ watts registered by the meter, whereas the actual wattage at the arc is, as in the former case, $48 \times 40 = 1920$ watts, so there is wasted in the resistance of the rheostat $8800 - 1920 = 6880$ watts, or about 3½ times as much energy as is actually employed in the production of light. On the other hand, if the voltage were only 60 or 70 then the waste in resistance would be correspondingly less, and it is for this reason why the author has always advised theatre managers when purchasing a light plant for their theatre to get a 60 or 70 volt generator.

From what has been said the idea may be gained that if direct current were generated at from 45 to 55 volts, or alternating current at 30 to 35 volts, it would be possible to operate without any resistance at all, thus eliminating all waste. This, however, is only true where generators of a certain type, built especially for this kind of work, are used. By the use of certain types of generators which in themselves automatically regulate the voltage, hence the current flow, it is possible to operate a projection arc without any resistance at all (See Motor Generator Sets, further on), but this cannot be done when using the usual type of generator. Resistance performs two functions, viz., regulates the am-

perage by regulating the voltage and supplies a steadying influence, or sort of "cushion" for the arc. Without this steadying influence, or its equivalent in another form, such as a generator of the type mentioned, the arc would be so unstable that it could not be handled at all; also it would not be practical to strike the arc in the first place, because when the carbons were brought together it would establish a dead, short circuit which would instantly blow the fuses.

Note.—I have said that all pressure above arc voltage represents waste, but this is not strictly true as applied to projection arcs taking current through rheostats. Under these conditions if the suply be below 60 volts the necessary resistance is not sufficient to steady the arc, therefore, strictly speaking, while the voltage between a 60 volt supply pressure and arc voltage represents waste, still it is *necessary waste,* whereas when the supply voltage is more than 60 all over that figure is *unnecessary waste.*

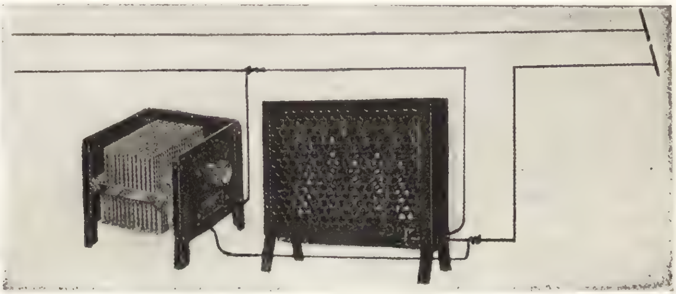


Figure 148.

Note b.—It may be remarked that traveling exhibitors have installed a small generator in an automobile and, using the auto engine for power, have operated a projection lamp without resistance in circuit. This is possible with a small generator working right up to capacity, but is not possible when taking current from power lines or a generator of considerable capacity.

Figuring Rheostat Connections.—In Fig. 148 we see an Edison adjustable, grid rheostat, with part of the casing removed to show the grid bank, connected in multiple with a Power's non-adjustable coil rheostat, both 110 volt instruments.

The Power's is a 25 ampere, 110 volt, and the Edison a 25 to 40 ampere, 110 volt rheostat. We will therefore get 25 amperes through one, and from 25 to 40 through the other, according to how the adjustment switch is turned. We will have a total current of from $25 + 25 = 50$, to $25 + 40 = 65$ amperes at the arc, with this combination. With the same two connected in series on D. C. we would get from 10 to 12+ amperes. It is figured as follows: The Power's is a 25 ampere, 110 volt instrument, therefore, has $(110 - 48) \div 25 = 2\frac{1}{2}$ ohms resistance. The Edison, when working at 25 amperes must have the same resistance, hence there will be a total of $2\frac{1}{2} + 2\frac{1}{2}$ ohms when they are opposed to the voltage in series. The resistance of the arc will be approximately 1 ohm, hence $(110 - 48) \div 2\frac{1}{2} + 2\frac{1}{2} + 1$ will equal the amperage when the Edison is on the 25 ampere contact. This is practically 10 amperes. If the Edison is set on the 40 ampere contact we would then have $(110 - 48) \div 40$ equal practically $1\frac{1}{2}$ ohms, which added to the resistance of the Power's makes $(2\frac{1}{2} + 1\frac{1}{2}) = 4$ ohms. We would, therefore, have $(110 - 48) \div 2\frac{1}{2} + 1\frac{1}{2} \times 1 = 12 +$ amperes delivery. If the current be A. C., then we would have $(110 - 35) \div 5 = 15$ amperes (not taking the inductive resistance into account); the A. C. arc voltage being 35, instead of 48 as in D. C.

Let it be clearly understood, however, that *these figures are only approximate.* It is impossible to be accurate for the reason that arc resistance varies with the length of the arc; also the rheostatic resistance varies with (a) temperature of the coils or grids; (b) with their age. Also, merely because a rheostat is stamped "110 volt, 25 ampere," it does not follow it has exactly the resistance this would indicate. Moreover, the supply voltage may not be just what you think it is.

As a matter of fact, a wire-coil rheostat rated at 25 amperes, and which delivers that amperage when new, will not do so after it has been used for a time. The resistance of wire coils rises gradually for a time, and then remains practically stationary until the coils finally give out entirely. When the resistance reaches its highest point it will usually be found that the "25 ampere" wire coil rheostat is really delivering about 20 amperes. After using a wire coil rheostat for a month or more you will be more nearly correct if you subtract five amperes from every 25 amperes of its rated capacity.

This may or may not apply to any considerable extent to cast iron grids. It is claimed that the resistance of cast iron remains constant, or practically so, but of this I am not certain.

Resistance Devices

EACH machine manufacturer puts out a rheostat, and some of them put out two or three different kinds. The Nicholas Power Company, for instance, puts out a grid rheostat and two or three different varieties of wire coil rheostats. I do not believe it is necessary to present illustrations of all these different devices, particularly in view of the fact that they all operate on precisely the same principle, and in exactly the same way. Wire coil rheostats are nothing more or less than a long piece of resistance wire coiled up into spirals in order to save space, the coils being mounted on an iron frame, from which they are thoroughly insulated, the whole being protected by a sheet metal guard or cover. The current enters at one binding post, flows through the resistance, and leaves at the other binding post. The rheostat is connected into either wire of the circuit, though most operators prefer the positive wire.

Figure 149.

Fig. 149 shows an ordinary rheostat "coil." In mounting this coil must be stretched just a little—enough so that the spirals will be at least 1/16 of an inch apart. This is important, by reason of the fact that if the spirals touch each other, then the current will simply jump through the coil, instead of flowing through the entire length of the wire. The effect of the spirals touching would tend to eliminate a large percentage of the resistance.

Fig. 150 illustrates one grid of a rheostat. It will be observed that it is, in effect, precisely the same as the wire coil illustrated in Fig. 149. To all intents and purposes it is a long wire made of cast iron coiled up to save space.

In Fig. 151 we see a photographic representation of an adjustable grid rheostat. Thirteen to 26, inclusive, are cast

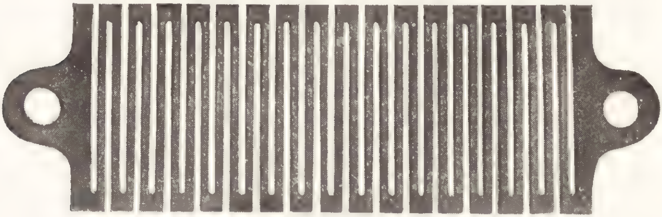


Figure 150.

iron grids, the same as the one illustrated in Fig. 143. The edges of these grids are protected from breakage by metal

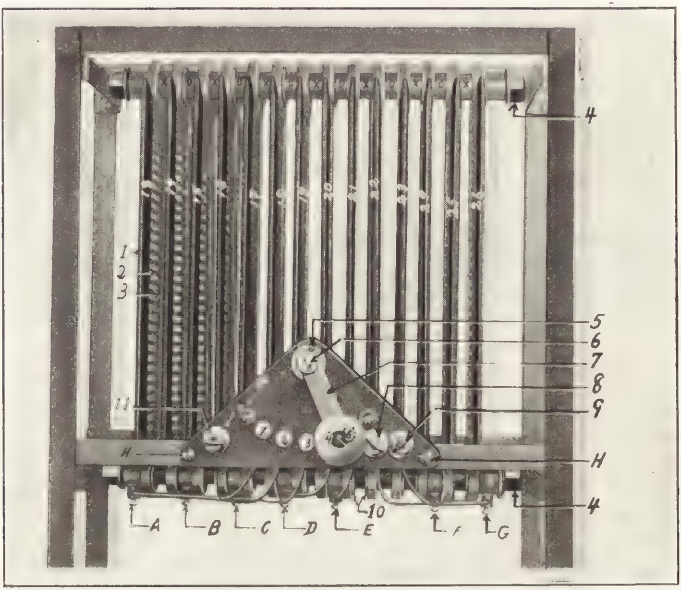


Figure 151.

guards, 1 and 3, Fig. 151, inside of which is a layer of asbestos insulation. At the top, X is a metal spacing

washer; next to it, 0 represents a similar spacing washer, but between it and the grids are insulating washers. Next comes another current carrying washer, and then another insulating washer, the whole being mounted on tie-rods 4-4. Now between grids 25 and 26 at the bottom end is an insulated spacing washer, and next to it, F is a current carrying washer, and so on. The grids are insulated from the tie-rods, therefore you will readily see that current entering at binding post 9 will pass through the connections to binding post G, thence to grid 26, up its length, across current carrying washer X, down grid 25, across current carrying washer F, up grid 24, and so on until it reaches an outlet. At the other end, 11 is a binding post to which the wire is attached, this post connecting to central switch post 6 through a wire, 12, represented by dotted line; 1, 2, 3, 4 and 5 are contact buttons connected to the grids at points A, B, C, D and E.

The lever is now on contact 5, so that current entering at binding post 9 will flow to binding post G and through the grids until it reaches binding post E, whence it will flow up through the wire jumper to switch contact 5, across the switch lever to post 6, down wire 12 to binding post 11, and thence to the lamp. This, you will readily see, "cuts out" grids 13, 14, 15, 16, 17, 18, 19 and 20. If we swing switch lever 7 over to contact button 1 the current must then travel through the grids until it reaches binding post A, whence it will flow to contact 1 and around through the switch lever and wire 12 to binding post 11, thence to the lamp. Therefore, with switch lever 7 on contact 1 you will be getting all the resistance that particular rheostat is capable of supplying, and will be reducing the voltage, and therefore the amperage as much as that rheostat will reduce it.

Binding post 8 is an auxiliary binding post not found on most rheostats. It is for the purpose of allowing the rheostat to be used on low voltage current.

With switch lever 7 on contact 5, and the wire connected to binding posts 11 and 9, you still have the resistance supplied by grids 21, 22, 23, 24, 25 and 26. This is what is known as the "fixed resistance" of the rheostat. If you desire to use the rheostat on current of very low voltage this resistance might be too much to supply the required amperage, and by changing the connection from binding post 9 to binding post 8 you will cut out coils 25 and 26, thus lowering the fixed resistance by one-third, and increasing the amperage accordingly.

This is made somewhat more plain in Fig. 152, in which the same numbers are used. By closely examining Fig. 152, you will observe the mica insulating washers, which are shown at 10 in both figures, you will see they are only used in alternate spaces. The Power Company puts this type of rheostat out for both 110 and 220 volt current. The weight of the 220 volt rheostat is practically double that of the 110 volt instrument.

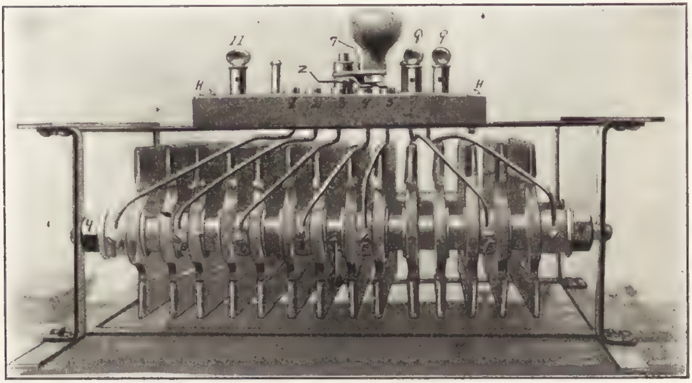


Figure 152.

In connecting a rheostat, wires are run from the main operating room cutout to one side of the machine table switch, and one of the contacts at the other end of the machine table switch is connected, using asbestos covered stranded wire, direct to one of the binding posts of the lamp. From the other machine switch binding post we run an asbestos strand covered wire to one (either) of the rheostat binding posts, and from the other rheostat binding post we run another asbestos covered strand wire to the other binding post of the lamp. Most operators prefer the resistance in the positive wire when using D. C., but it really does not make any particular difference which wire it is in.

The rheostat shown in Fig. 151 may be disassembled by removing its cover, and loosening nuts 4-4 which hold the grid bank together. Having removed these nuts the grids can be slipped off the tie-rods. *In reassembling be very sure*

you get the insulating and current carrying washers X and O in their proper relation. If you don't you will have trouble. Also when the reassembling is complete be sure to set up tie-rods 4-4 good and tight.

Caution.—Be sure that lever 7 makes firm contact with the contact buttons, since otherwise there will be arcing and heating. Should these contacts become roughened after a time, carefully dress them up with No. 00 emery cloth or paper, at the same time smoothing up the contact face of the lever. Wrapping the emery around a small file will enable you to do a better job. All adjustable rheostats have the same connections as the one shown in Fig. 151, except that few have auxiliary binding post 8. The 220 volt grid rheostat is connected into the circuit just the same as is the 110 volt one.

Some rheostats are adjustable, and some are non-adjustable, the latter usually having two binding posts to which wires are connected. They offer fixed resistance which cannot be changed. This kind of resistance is not the best, however, for several reasons, one of which lies in the fact

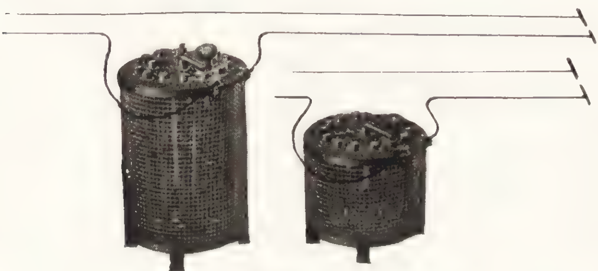


Figure 153.

that a new rheostat has considerable less resistance than it has after it has been in use for a time. Therefore, if for no other reason it is desirable that one be able to cut out some of the coils when the resistance becomes greater through use.

As between the grid and wire coil rheostat I would advise the wire coil for road use, by reason of its comparatively light weight, and the grid rheostat for theatrical use, because it is rugged in its construction, deteriorates much less rapidly and, therefore, lasts longer. For road use the Nicholas Power Company puts out a wire coil rheostat made in round form, illustrated in Fig. 153.

My reason for recommending this rheostat is it is light in weight and very flexible in its electrical action.

In Fig. 154 the top of this rheostat is shown at A, on the left. Connections are made to binding post B-B, and all the coils from 1 to 14 are thus placed in series with each other, but since binding post B connects to the central switch post by means of a copper jumper the current will only pass through the number of coils necessary to reach the lever. Therefore, if the lever is on contact 4 the resistance of coils 1, 2 and 3 would be eliminated. At B, on

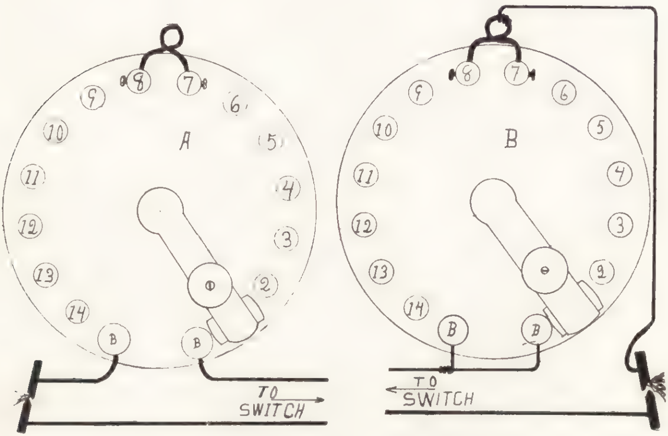


Figure 154.

the right, this rheostat is shown with its two sides in multiple. It is the same as though you connected two rheostats, each one having the resistance supplied by half the total number of coils in the rheostat, in multiple. The current enters at binding posts B-B, flows through the coils on the left to 8 and through the coils on the right to 7, and thence to the lamp. You thus get the full capacity of these two banks of coils, but this can only be used on 110 or less voltage, whereas the connection at A can be used on current up to 240 volts. When using connection B, Fig. 154, the lever must be set on contact 1. Possibly you can increase the current somewhat by moving it to contact 2 or 3, but beyond that the remaining coils on that side will most likely get red hot.

The Transformer

THE transformer is a device for changing alternating current of a given cycle (frequency) and voltage to the alternating current of the same cycle but of a different voltage and amperage. In general, the volts times amperes taken from the supply line is equal to the volts times amperes (volt amperes) given off at the secondary, less the loss in the transformer itself, which loss varies from 10 to 20 per cent.

The standard transformer is made up with two separate coils which are insulated from each other, one coil being called "primary" and the other coil being called "secondary." There are modifications of transformers which are designed as "auto transformers," in which the transforming action is obtained more efficiently than with a straight transformer, but in which the windings are not insulated from one another, the secondary winding becoming a part of the primary winding. To this class belong most transformers used in the operating rooms for controlling the projection arc. Another modification is a reactance coil, or choke coil, as it is sometimes called. In this device the choking effect of the transformer is obtained, but the amperes taken from the secondary side will always be the same as on the primary side, although the volts on the secondary side will differ from the volts on the primary side. This device is less efficient than either the transformer or auto transformer.

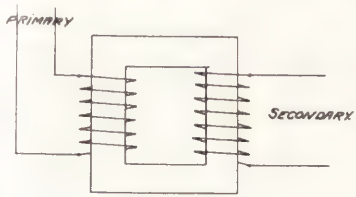


Figure 155.

A transformer (or auto transformer) may either increase the voltage and decrease the amperage, in which case it is called a step-up transformer, or it may decrease the voltage and increase the amperage, in which case it is called a step-down transformer.

Fig. 155 represents the diagrammatic connections of a straight transformer. It will be noted that the windings

are independent of one another, although they both surround portions of the same core or magnetic circuit.

Fig. 156 represents the diagrammatic arrangement of an auto transformer. It will be noted that with the two windings connected together so as to form practically one coil, due to the fact that the current in the primary is transformed through only a part of the winding, the losses become less than the losses in the transformer represented in Fig. 155. This results in a smaller and more efficient construction than in the straight transformer.

Fig. 159 is a diagrammatic connection of a reactance or choke coil. With this arrangement no saving in wire size is possible, because the same amount of current (amperes) consumed in the arc must be taken from the line.

In a transformer or auto transformer the amount of current in secondary depends on the ratio of turns (number of turns primary divided by number of turns secondary). If the primary winding were made up with 20 turns and the secondary winding made up with 10 turns, this would be a ratio of 2 to 1, and each two amperes in the secondary would require one ampere from the primary. The volts on the secondary, however, would be only one-half of the volts on the primary.

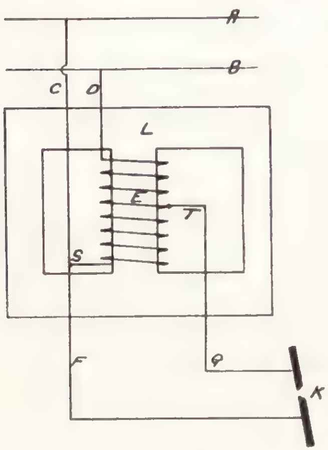


Figure 156.

Referring to Fig. 157, A and B are the wires of the supply circuit; C and D are wires leading to the primary coil from the main supply wires; I and J are wires leading from the secondary coil to arc lamp K; L is the laminated iron core.

The primary and secondary coils may be wound one over the other and inserted in the opening in the core, or they may be wound as shown, or in other ways, the method in Fig. 155 being merely selected to show the idea. The wires of the coils are themselves covered with a special form of insulation. The coils are insulated from the iron core.

Neither coil has any mechanical or electrial connection of any kind whatsoever with the other coils or the core.

The core itself is built up of thin sheets of annealed steel. It is essential that these sheets be very thin, the exact thickness depending on the frequency of the current. Each sheet is painted on both sides with an insulating compound, or other methods to insulate are used, after which the sheets are clamped firmly together and the primary and secondary coils are wound on the core thus formed, over a layer of insulating material, and the two coils and the core form the transformer.

The action is as follows: When the switch on the primary side is closed the current which flows through the primary coil magnetizes the iron core and sets up a powerful magnetic field, which has the effect of making a choke coil out of the primary coil, and a choke coil so powerful that practically no current at all will flow when the secondary circuit is open. The magnetic field thus created surrounds both primary and secondary coils, so that while these coils have absolutely no mechanical connection with each other or with the core, and are, in fact, thoroughly insulated from the core, they do have a *magnetic* connection, which acts as follows:

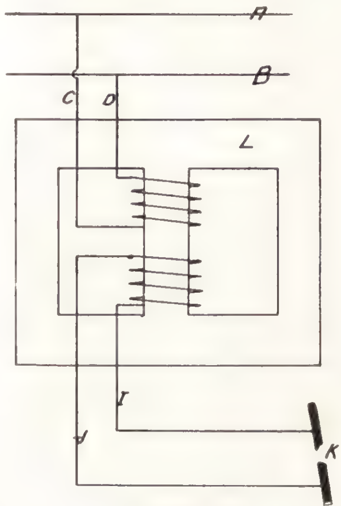


Figure 157.

It is one of the laws of electricity that all wires carrying alternating current are surrounded with what is known as a "magnetic field"; that is to say, for a certain distance surrounding a wire carrying A. C. the air is permeated with magnetism. Now if another wire be placed within this magnetic field, as per Fig. 158, although there be no mechanical connection of any kind between the two wires, if wire A carries A. C. then there will be an induced electro-motive force set up in wire B, though under the conditions set forth the effect would be too slight to be perceptible except to a

very delicate galvanometer. Fig. 158 merely illustrates the theory upon which the transformer depends for its action. In transformers instead of wire A we have a great many wires in the primary coil or rather one wire passing through the magnetic field a great many times, and instead of wire B a great many wires in the secondary coil, or one wire passing through the magnetic field a great many times. We also have an iron core which enormously intensifies the magnetic field, and thus the feeble action in wire B, Fig. 158, becomes enormously powerful, and we have the "transformer."

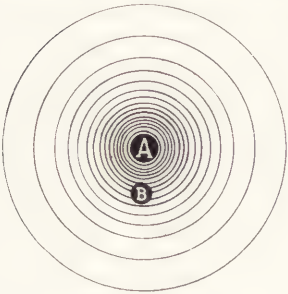


Figure 158.

The action of the transformer is entirely automatic, and it depends entirely for its action on magnetic inductance. The secondary current in flowing through the secondary coil magnetizes the core, but in the opposite direction to the primary, therefore when current flows in the secondary the primary current increases just enough so that combined effect of the two windings remains the same. It therefore follows that when the load of a transformer is increased the primary winding automatically takes additional current from the supply wires just sufficient to supply the added load on the secondary, therefore the automatic action of the transformer depends on the balanced magnetizing action of the primary and secondary circuits.

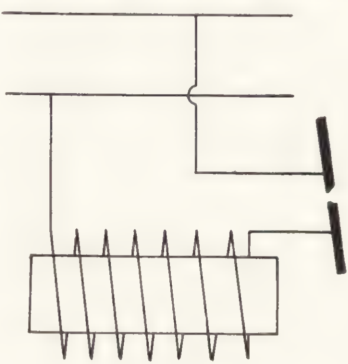


Figure 159.

Referring to Fig. 156, A and B are the supply lines, C and D are the wires feeding the auto transformer, E the winding, including both primary and secondary, F and G the wires feeding the arc K, and L is the iron core.

It is to be noted the entire coil E is connected across the

supply lines and that a tap T is brought out so that the section of E from S to T forms the secondary while the whole coil forms the primary. The action electrically and magnetically is the same as in a standard transformer.

The choke coil, also called a "reactance" coil, Fig. 159, represents what might be called magnetic resistance. If an iron core consisting, in practice, of thin sheets of metal, be built up, and one of the insulated wires of an alternating circuit be wrapped a number of times around it, as shown, there will be a magnetic kick or reactance set up, which will have the effect of offering resistance to current flow. This is called "magnetic kick," or "reactance." The practical effect upon current flow is essentially the same as that of the rheostat. The magnetic field set up around the core of the coil has the effect of creating a counter E. M. F., which opposes the line voltage and reduces it. The choke coil is, however, very much more economical in operation than is the rheostat, but is not nearly so satisfactory for the production of projection light as is the transformer or auto transformer, largely by reason of the fact that it has a tendency to produce flaming at the carbons, and where it is used difficulty is found in concentrating the crater into a small area. The transformer has, of course, a power factor, but I hardly think any good purpose will be served by going into that matter, particularly in view of the fact that the author can no longer recommend the use of operating room transformers. True these instruments are quite efficient and by their use a very good illumination may be had. Still, the use of alternating current at the projection arc is out of

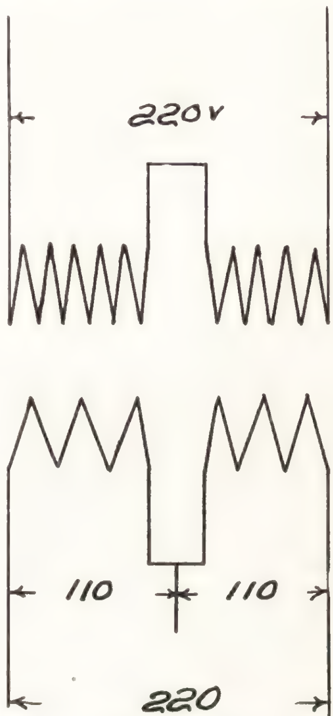


Figure 160.

date, and ought to be entirely discontinued. Motor-generator sets and mercury arc rectifiers have been brought to a high state of perfection, so there is now no good reason why alternating current should be used for projection purposes, nor is its use efficient, when viewed from the standpoint of curtain brilliancy. By this I mean that, whereas it is possible to secure practically as excellent an illumination with alternating current as with direct current, still it will take practically double the amperage to do it. In fact, for a picture of given size a better screen result will be had with 25 amperes D. C. than with 50 amperes A. C., and in order to get the same result in illumination as that produced by 40 amperes D. C. it would be necessary to use fully 80 amperes A. C. Therefore, even allowing that the transformer has a higher efficiency than the rectifier or motor-generator set, still if equal screen illumination is had it will cost more to use A. C.

Where the coils are wound around opposite legs of the core, as in Fig. 155, the transformer is called a "core" transformer; where the coil is wound around the central leg of the core (inside the outer legs of the core) it is known as the "shell" type, Fig. 157.

Please let it be understood that I am not entering into all the details of transformer construction. The details of construction have much to do with the efficient performance of a transformer, but all I seek to accomplish in this article is to give the operator a fairly comprehensive understanding of the theory upon which the transformer works—not to give him instructions enabling him to build one. That calls for very careful calculations and experiment, which can only be made by a duly qualified electrical engineer.

Transformers may be built to deliver current to a three-wire secondary from which two voltages may be had; for instance, 220 and 110. This is illustrated in Fig. 160. As a matter of fact usually alternating current three-wire systems are two-wire circuits up to the transformer, and beyond the transformer become three-wire systems merely by either the peculiarity of construction of the transformer or the method of hitching up two transformers.

The operator is as a general proposition only interested in the theory of the transformer and the practical operation of the low voltage transformer commonly called "compensarc," "economizer," "inductor," which ordinarily takes 110

or 220 volts supply from the line and delivers secondary current at arc voltage, and this is the type of transformer to which we will devote our attention.

As has already been remarked, volts times amperes taken from the line equals volts times amperes delivered on the secondary, less the loss in the transformer which, as I have already remarked, may run anywhere from 10 to 20 per cent.

In operating a projection arc lamp it is necessary at times to vary the amperes. Now the secondary of a transformer works against a slight resistance of the secondary circuit wires and a considerable resistance of the projection arc, therefore the current flow against this particular fixed resistance can either be increased or decreased by increasing or decreasing the voltage of the secondary.

As has already been remarked, the voltage of the secondary will depend upon the relative number of turns in the primary and the secondary coil. The greater the number of turns in the primary with relation to the number of turns in the secondary the less the voltage of the secondary.

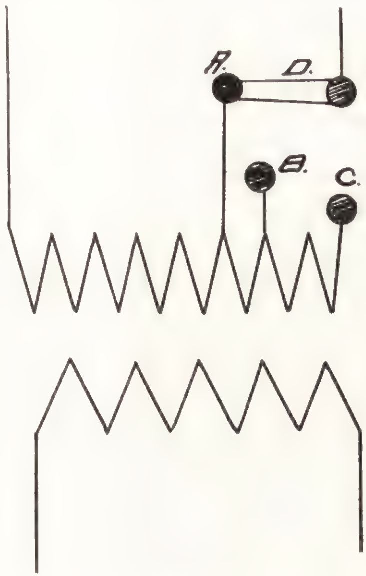


Figure 161.

It is a known fact that the best voltage across an alternating current arc is approximately 35 volts. In order to keep the arc burning steadily it is always necessary to have a steadying resistance or a reactance in the arc circuit. One advantage of reactance for steadying the arc is that there is very little power lost in the reactance, whereas with resistance all of the steadying effect is turned into heat, and, therefore, means a lot of lost power. Reactance can be obtained only on alternating circuits.

In order to change the current at the arc it is necessary, therefore, to change the steadying reactance when using a

transformer or auto transformer. This is done in different ways. In some cases the turns in the primary are changed, and in this way the reactance, or magnetic choking, is changed so as to change the value of current at the arc.

This fact is taken advantage of as per Fig. 161, in which A, B, C are buttons and D a lever which completes the circuit of the primary coil through one of these buttons. It will readily be seen that if lever D be on button A the number of turns in the primary will be decreased, and, since the turns in the secondary remain fixed, the voltage of the secondary and consequently its amperage will be raised. By moving lever D to button B or C the number of turns in the primary is increased, and, therefore, the voltage and amperage in the secondary is decreased.

Another scheme, used in the Fort Wayne A. C. compensarc, is to have small additional reactance coils, which are cut in or cut out of circuit by means of a switch. These are placed in the secondary circuit, so that the secondary voltage

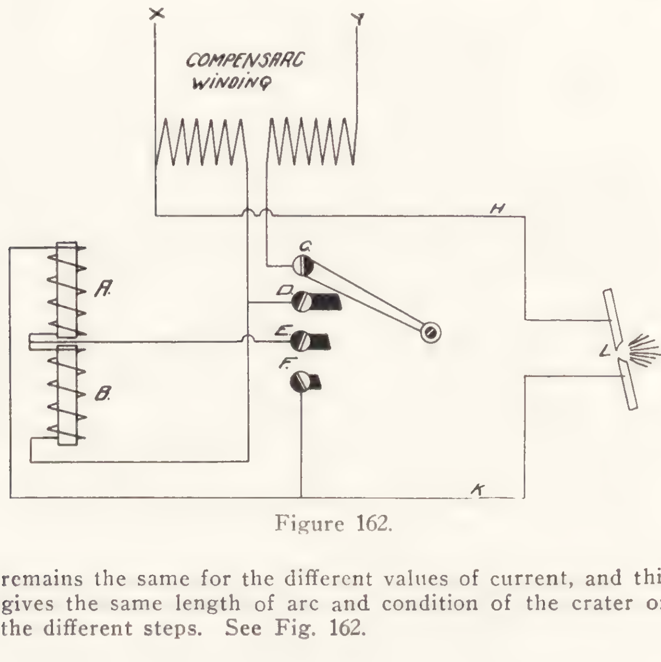


Figure 162.

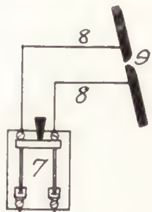
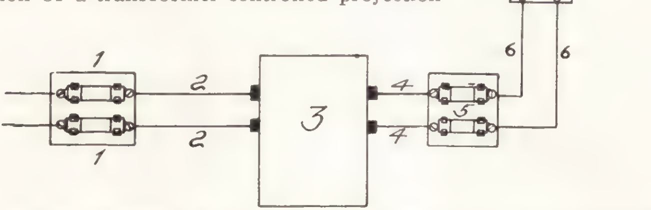
remains the same for the different values of current, and this gives the same length of arc and condition of the crater on the different steps. See Fig. 162.

Fusing Projection Circuits Where Transformer is Used.— Let it be clearly understood that the term "transformer," as here used, means the low-voltage transformer commonly termed "Economizer," "Inductor," "Compensarc," etc. Before reading this, however, I would recommend the operator to turn to Page 343, and study the electrical action of these devices.

When dealing with transformers it must be clearly understood that one ampere from a 110 volt line becomes considerably more than two amperes at the 35 volt projection arc, and that one ampere from a 220 volt line becomes approximately between five and six amperes at the 35 volt arc. Let it also be clearly understood that, for the purpose of calculating, we assume the voltage of the A. C. projection arc, and therefore the voltage of the secondary of the transformer, to be 35, although it may range anywhere between 30 and 40.

This brings about a peculiar and apparently very little understood condition as applied to fusing. Almost all transformers (remember I am speaking of economizers, etc.) are fused on their primary side only. This is bad practice.

Fig. 163 is the diagrammatic representation of a transformer-controlled projection

Note.—Error: Switch 7 should be between fuses 1-1 and transformer 3.

Figure 163.

circuit in which 1-1 are the fuses at the beginning of the primary circuit, either at the operating room distribution panel or the main house switchboard, as the case may be; 2-2 are the lines from 1-1 to the transformer; 3 is the transformer; 4-4 the lines from the transformer secondary to fuses 5, and 6-6 are the lines from secondary fuses 5 to machine table switch 7. All these may be rubber covered wire, but lines 4-4 and 6-6 must be of sufficient size to ac-

commodate the full amperage capacity of secondary fuses. Line 2-2 should not be less than No. 6 B. & S., and it would be still better to have them No. 4, because it may become necessary, in case of breakdown or for some other reason, to remove the transformer and substitute a rheostat, in which case you would not want to pull less than 50 or 60 amperes, and No. 6 R. C. is only rated at 50, No. 5 at 55, and No. 4 at 60 amperes.

The ordinary procedure is to install wires 2-2 just large enough to carry the secondary capacity of the transformer, but, for reasons already set forth, this is not the best practice. If wires 4-4 and 6-6 are rubber covered, then No. 4 must be used, since practically all transformers (economizers, compensarcs, inductors, etc.) have a 60 ampere secondary capacity, but if wires 4-4 and 6-6 are asbestos covered, they come under the weatherproof rating, and No. 6 is large enough, since No. 6 weatherproof is rated at 70 amperes. Wires 8-8, from machine table switch to lamp, must be asbestos covered stranded No. 6, unless a special transformer delivering more than a 70 ampere secondary current is installed, in which case they must be large enough to accommodate the current. Fuses 1-1 are merely designed to protect wires 2-2 and the transformer primary coil, but inasmuch as No. 6 wire will accommodate nearly three times the primary current capacity of the transformer, they really, in effect, protect only the transformer primary coil, and for the ordinary economizer delivering a maximum of 60 amperes at the arc, they should be 30 ampere capacity. Some transformers will deliver more than 60 amperes secondary, especially if the voltage be a little higher than rated, but you will find that 30 ampere fuses will meet all requirements. The secondary may be fused to 65 amperes, which will give a 5 ampere leeway. But, however, if 65 be found insufficient, no harm will be done by installing others of 70 ampere capacity.

The reason for requiring fuses on the secondary as well as on the primary are twofold; First, some operators and managers locate the transformer outside the operating room, even putting it down in the basement. This is very bad practice, but nevertheless they do it, and then, exercising still more and greater bad judgment, stick 50 or 60 ampere fuses on the primary. The inspector is not likely to see it, because it is an out of the way place. *For practical purposes they may just as well not fuse at all,* because with 110 volt transformers, 60 ampere primary fuses would deliver about 150 amperes on

the secondary, whereas with a 220 volt supply it would give nearly 300. Second, except in small sizes, cartridge and plug fuses are only made in multiples of 5 amperes, that is to say 20, 25, 30, 35, etc. Now with a 110 volt supply 30 ampere fuses will deliver approximately 60 amperes on the secondary, but the capacity of the fuses and of the transformer is so nearly alike that there might be trouble with 30 ampere fuses blowing. If, however, you install others of 35 ampere capacity, the next size, it makes a possible difference of between 10 and 15 amperes at the arc, with the 110 volt supply, and between 20 and 30 amperes with the 220 volt supply, whereas 5 amperes difference in the fuses on the secondary means 5 amperes, and no more; therefore it is possible to fuse much more rationally on the secondary than it is on the primary.

Compensarcs

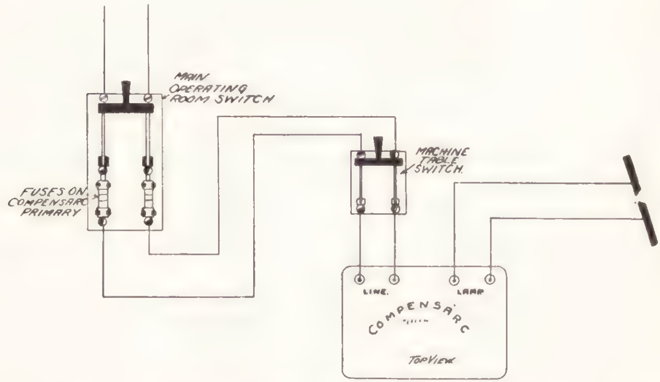
ALTERNATING CURRENT TYPE A, FORM 4

This device is manufactured by the Fort Wayne Electric Works for use on alternating current circuits only. It is self-contained and requires no auxiliary rheostat or other controlling mechanism. *Before installing the compensarc examine the name plate to see if the rating agrees with the frequency and line voltage of your service.*

Place the compensarc directly beneath the lamp house of the projection machine if possible, otherwise in some position convenient to the operator to allow him to adjust the amperage of his arc. Connect both wires from the Power Company's service through a double-pole, fused switch to the two terminals of the compensarc marked "LINE." Connect two terminals marked "LAMP" to the projection arc terminals through the double-pole operating switch on the projection machine. As this is an A. C. device there are no positive or negative wires.

Figure 164.

Fig. 165 is a diagram of connections for the A. C. compensarc. The primary or line wires should be fused to about half the maximum current at the lamp. This would ordinarily require about a 30-ampere fuse.



Note.—This diagram supplied by the manufacturer. The author does not agree with omitting fuses from the secondary circuit. See Fig. 163.

Figure 165.

This device is adjustable in three steps, which steps have been found to meet the general service conditions.

When the switch on the compensarc is open no current flows through the lamp, but the operator should not handle his carbons without opening the operating switch on the projection machine, because if the outside lines have a ground and the operating room is grounded the operator can receive a shock of full-line potential. When through with the show open the primary line switch.

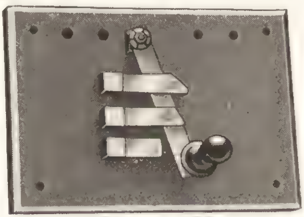


Figure 166.

Fig. 166 shows the slate top of the A. C. compensarc and the switch blade. Throwing the switch blade in contact with the first clip of the switch (Fig. 166) gives an adjustment so that with the carbons separated about three-sixteenth of an inch the current flowing through the projection lamp

will be approximately 30 amperes. In contact with the second clip of switch the adjustment changes so that approximately 40 amperes flow through the arc. Throwing the switch blade over to the third clip allows approximately 60 amperes to flow through the lamp. The manufacturer recommends the use of five-eighths-inch cored carbon upper and lower.

In order to determine if your compensarc is in good condition on all three steps, first, start the arc on any one of the steps, then jump the switch quickly to the other two steps in succession, watching the light. There should be an appreciable difference in the light, which you should be able to detect in trying this several times. If you think the compensarc is heating too much do not attempt to judge the temperature by your hand; use a thermometer on the hottest part. Lean the thermometer in contact with the hottest part for 5 or 10 minutes and the temperature should never exceed 40 degrees C. or 72 degrees F. above the room temperature.

To obtain the best results carefully observe the following:

(1) Make sure the two leads marked "lamp" are connected to the projection arc lamp through operating switch on the projection machine.

(2) Always open operating switch on projection machine when changing carbons, to eliminate possibility of shock due to grounds on the power system.

(3) Connect to leads marked line directly to the power line through a fused double-pole switch. When through using the compensarc open the line switch.

(4) Never connect any resistance in series with the compensarc either on the line or lamp side.

(5) Be sure the line voltage and frequency agree with the voltage and frequency marked on compensarc nameplate.

(6) Be sure all connections are perfectly clean and tight and see that adjusting switch has not been damaged in shipment.

(7) Do not try to use any more current than is required to obtain a good picture.

(8) Do not overload your carbons, as this will produce a very noisy arc.

(9) Do not separate carbons too far; a three-sixteenth-inch separation on five-eighths cored carbons will give good satisfaction with 40 amperes.

THE EDISON ECONOMY TRANSFORMER

The Edison Company claims a very high efficiency and a simple adjusting mechanism for its transformer, which is illustrated in Plate 1.

Wiring Connections.—The device has five leads entering. At one side, directly under that part of the top in which the word "Lamp" is cast, are the secondary wires, which are to be connected directly to the arc lamp, either wire to either lamp binding post.

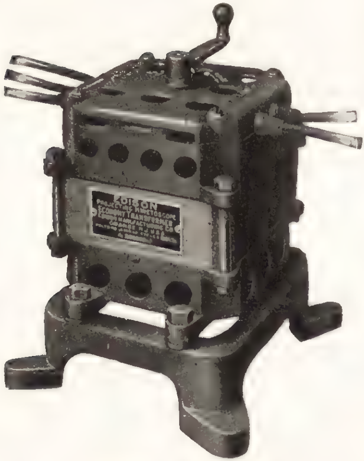


Plate 1, Figure 167.

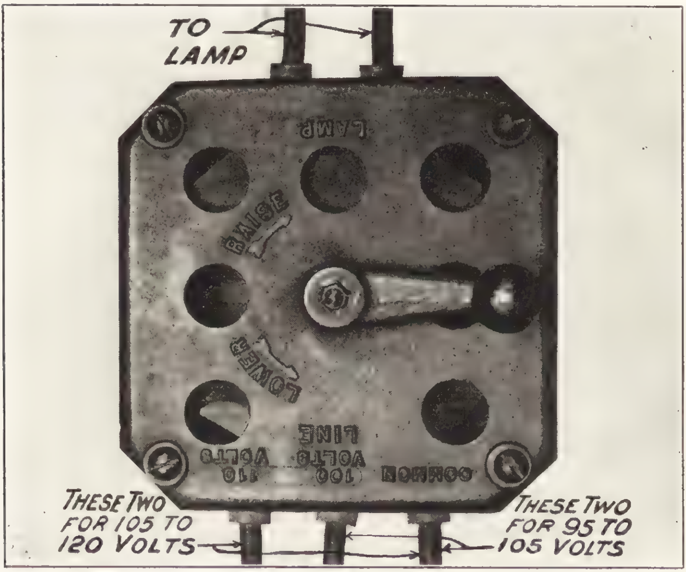


Plate 2, Figure 168.

The three wires entering the opposite side are the primary lines. The wires directly under the word "Common" must always be connected to one side of the line switch. One of the other two wires should be connected to the other side of the line switch, but which one is to be so connected will depend upon the line voltage. This is all made clear in Fig. 168, so that no mistake can possibly be made. The end of the wire not in use must be carefully wrapped with insulating tape and left dead.

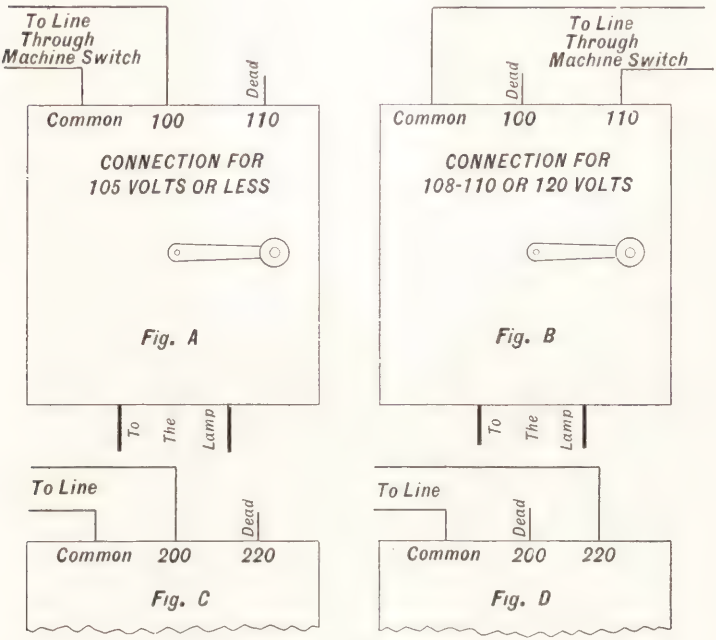


Plate 3, Figure 169.

For further information see the wiring diagram in Fig. 169, which gives all necessary information with regard to both the 110 volt and 220 volt transformer connections.

Range of Adjustments.—In Plates 1 and 2 you see a handle or crank on top of the transformer. This handle operates adjusting plugs which vary with the current at the arc. Cast into the cover on top of the transformer case, Plate 2, are

two arrows, marked respectively "Raise" and "Lower." Turning toward "Raise" you will raise the voltage, and hence the amperage at the arc; the opposite direction lowers the voltage, hence the amperage at the arc. The crank or handle raises or lowers leakage plugs in the magnetic circuit, the same being placed between the primary and secondary windings, thus increasing or decreasing the strength of the magnetic field.

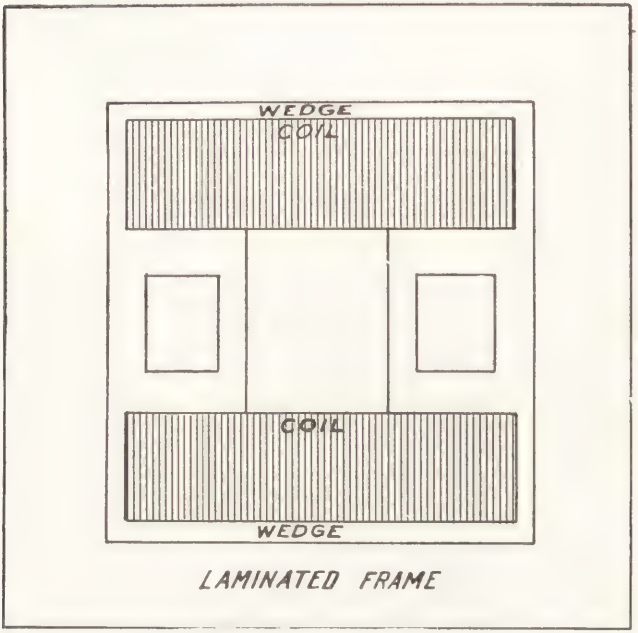


Plate 4, Figure 170.

The primary and secondary windings are secured to the iron core by means of wooden wedges, as per Plate 4. These wedges must be tight enough to hold the windings rigid. If the windings are loose, so that you can move them with your hands when the top casting is removed, then the wedges should be driven tighter. To do this it is only necessary to remove the top and slip some thin, blunt instrument down between the windings and the frame to the top of the wedges

and drive them down further. Plate 4 shows the transformer with the top cover casting removed. To remove the cover, take out the four round head screws shown in Plate 2.

The Edison transformer is claimed by its manufacturers to be practically noiseless in operation, and should it at any time become noisy there are three adjustments which may require attention: (a) The nut on top of the handle (crank) may have become loose. The screwshaft to which this handle is attached is fitted with a shoulder below the casting, and between this shoulder and the under side of the top casting is a spring washer. It is necessary that the nut on top of the handle be set up sufficiently tight to compress this washer flat. This means the nut should be set up moderately tight, though, of course, not tight enough that the handle will turn too hard. (b) The leakage plugs are fitted at their sides with phosphor bronze springs. These springs hold the plugs rigid between the walls of the supporting guides. Should they fail of this purpose, then they must be bent to give greater tension. (c) The thread in the shaft to which the handle is attached should make a good fit in the crosspiece to which the plugs are fastened. A loose fit at this point will not make the transformer exactly noisy, but may cause it to hum.

Operation.—After connecting the transformer, close the line switch and the operating switch and strike the arc in the usual way, after which turn the adjusting handle until you get the desired result on the screen. This will, of course, vary with size of the picture, etc. Under varying conditions it may be necessary to work with the handle clear down or clear up. Ordinarily, however, a position somewhere midway should meet the requirements.

POWER'S INDUCTOR

Power's Inductor, Fig. 171, consists of a well insulated, strongly clamped laminated core with the primary wound on one side or leg of the core and the secondary on the other. The casing consists of a cast-iron front and back, with a perforated brass cover. On the front, at the top, two wires emerge, underneath which, on the casting, is the word "lamp." These two wires connect directly to the carbon arms of the projector lamp. It makes no difference which wire you connect to the upper or lower carbon arm. At the back side, near the top, the two primary leads come out. They should be connected to the supply, as per Fig. 163,

Page 351. On the face of the front casting is a hand-wheel which operates a single-pole knife switch, located on the opposite side of the casting. When this switch is thrown so that its finger points toward "high" you are getting the maximum amperage, approximately 65. When it points to "medium" you are getting a medium amperage, and when it points to "low" you are getting the lowest amperage the transformer will supply.

Figure 171.

The inductor is designed for a maximum of 65 amperes on "high," 54 on "'medium," and 45 on "low" when used on 110 or 220 volts, it being, of course, understood that you cannot use 110 volt inductor on 220, or a 220 on 110. In other words, you must have an inductor suitable to the voltage of your supply; also it must be suitable to the cycle of the current you use, though the inductor may be used on voltage ranging 10 per cent. below to 10 per cent. above that for which it is rated, but in one case there will be a corresponding increase, and in the other a decrease in its rated amperage. The inductor is designed for a maximum temperature rise of 50 degrees Fahrenheit above the surrounding atmosphere, and ordinarily its temperature will not exceed 30 degrees in excess of the surrounding air. It occupies 12 x 14 inches floor space, is 19 inches high, and weighs approximately 100 pounds. Its efficiency rating will compare favorably with other machines of its kind.

THE HALLBERG ECONOMIZER

The "Hallberg" A. C. to A. C. economizer is nothing more or less than a transformer of the semi-constant current type, specially designed for use in moving picture projection arc circuits, taking A. C. at line voltage and delivering A. C. at arc voltage. "Semi-constant" means that it will receive supply at a fixed potential, but will deliver at the arc practically steady amperage flow, regardless, within reasonable limits, of the length of the arc.

The device consists of a continuous, rectangular core, on one leg of which is wound a primary coil, and on the opposite

leg a secondary coil, the latter being of larger, heavier wire than the former, to which the arc lamp is connected.

In Fig. 165 we have a view of the top of the Hallberg Economizer showing the various taps coming out. The two marked "to lamp" are the terminals of the secondary coil, which attach, through fuses, to the arc lamp, as per Fig. 163. The terminal marked "1," Fig. 172, is the constant, and must always be connected to one side of the source of supply. Either one of terminals "2" "3," or "4," Fig. 172, may be connected to the other side of the supply, according to the supply voltage and the amperage desired at the arc.

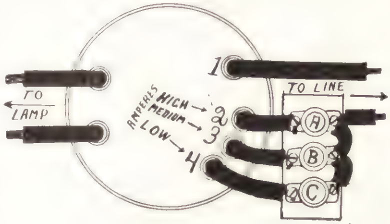


Figure 172.

Terminal "4" represents one end of the primary winding, of which terminal "1" is the other end. A, B, C are fuse receptacles, and leads "2" and "3" are taps connecting to the primary coil as per Fig. 154, Page 342. Now if a fuse plug of sufficient capacity to carry the primary current be placed in receptacle C, receptacles A and B being empty, then as you will readily see, the whole of the primary coil will be in use. This connection is designed for use where the primary voltage is a little above normal, or when you require the lowest amperage the economizer will deliver. If the fuse be removed from C and placed in A, then several turns of the primary coil will be cut out, which will have the effect of boosting the secondary voltage, and hence the amperage at the arc. The fuse plug should be in receptacle A when the line voltage is a little below normal, or when the highest available amperage is desired at the arc. CAUTION: Do not unscrew the fuse plug while the arc is burning. If you do the current will arc and burn out your fuse receptacle; otherwise this arrangement is cheap, practical, and should never give trouble.


Figure 173.

Fig. 173 shows the appearance of the Hallberg economizer. *The machine table switch should always be on the line side of the economizer.*

The economizer is supplied for voltage ranging from 100 to 120 and 200 to 220, and may be constructed for 25, 35, 40, 50, 60, 120, and up to 140 cycles. The 110 volt economizer lines are usually connected to terminals 1 and 2 when the voltage is 100 to 105; to 1 and 3 between 105 and 115, and to 1 and 4 if between 115 to 120. If it be a 220 volt economizer then connect to 1 and 2 for 220 volt supply and to 1 and 4 for 240.

The manufacturer supplies the following data for the Hallberg economizer.

Line fuses required.	Line Voltage.	Line Amperes.	Line watts per hour.	Amperes at arc.
	Regular	*Type*—30-40	*Amperes.*	
20	110	18	1,400	30-40
10	220	9	1,400	30-40
	Standard	*Type*—45-55	*Amperes.*	
30	110	25	1,800	45-55
15	220	13	1,800	45-55
	Special	*Type*—60-80	*Amperes.*	
40	110	35	2,200	60-80
20	220	18	2,200	60-80
	Searchlight	*Type*—125-150	*Amperes.*	
80	110	75	4,200	125-150
40	220	35	4,200	125-150

There are four types of this device, viz: the "Regular," the "Standard," the "Special," and the "Searchlight." The Regular type is designed for stereopticon and very light motion picture theatre work, where the picture is small and the performance not continuous.

The Standard type is recommended by the manufacturer for ordinary motion picture theatre performances. It delivers a maximum of approximately 60 amperes at the arc.

The Special type is made for those who desire an amperage in excess of 60, and is size the author recommends to those who want brilliant screen illumination.

The Searchlight type was ordinarily designed for Kinemacolor work, but it is now offered to the regular motion picture trade. It has a maximum capacity of 150 amperes.

Where the Searchlight is used it is well to use either three-quarter or seven-eighth inch cored carbons. Where the Special and Searchlight economizers are used the asbestos covered cable should be No. 4 for the Special, and No. 2 for the Searchlight. For all other economizers they should be No. 6.

PREDDY ECONOMIZER

The Preddy Economizer, the general appearance of which is shown in Plate 1, manufactured by Walter G. Preddy, San Francisco, consists primarily of two parts, viz., a heavy laminated sheet metal core, 16 inches in length, around which is placed a winding consisting of two layers of No. 4 magnet wire. The first or inner layer is wound directly over the core, but insulated therefrom. The second, or outer layer is wound over the first, and has brass taps brought out on every seventh turn. These taps are so arranged that the windings may be tapped at eleven points, thus providing for a greater or less amount of inductance, according to the number of amperes it is desired to use at the arc. The taps are labeled "contacts" in Plate 2, the wire terminating in an arrow head, labeled "clamp," connecting to one of the contacts. The two-screw connection at the top of the coil, and the brass tap at the same end, are at the extreme ends of the windings, all other taps being interposed, and acting to cut in or out a certain number of turns of wire, thus varying the inductive effect, and hence the amperage at the arc.

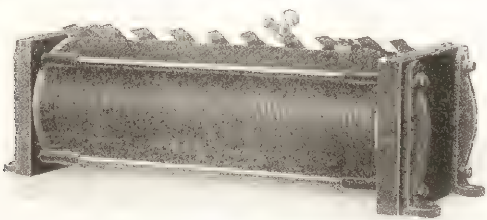


Plate 1, Figure 174.

The Preddy Economizer is an economy coil, inductance coil, reactance coil, or choke coil, those names meaning the same thing and applying equally to the same apparatus. The more familiar term is choke coil. There are no switches or levers to manipulate; all the regulation is perfected by means of the clamp and contacts, Plate 2, as already described. The connector (clamp) is merely a slotted brass casting that slips on the taps, and is then screwed tight by hand. CAUTION: Never use pliers in making this connection.

Directions.—The Preddy Economizer is not a transformer or auto-transformer, and has no "primary" or "secondary"

winding. It is connected into the arc lamp circuit precisely the same as you would connect a rheostat. See B, Fig. 142, in which just substitute a Preddy coil for rheostat C. It is advisable to use (manufacturer's recommendation) wire not smaller than No. 6, and fuses not smaller than 75 amperes. There is no reason for placing fuses on the lamp side of the Preddy Economy Coil, as is advisable with the transformer, since the amperage is the same on both sides of the Preddy device.

Never attach the economizer to a metal lined wall unless you first remove the metal or place a marble or other insulating or

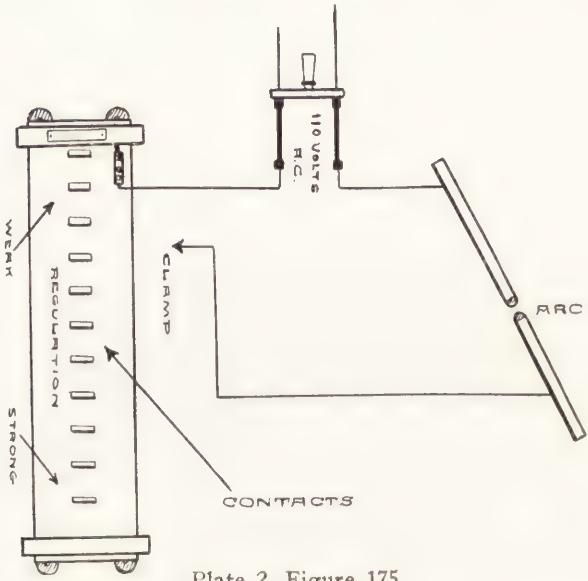


Plate 2, Figure 175.

non-metallic material of substantial thickness between the economizer and the metal. If the device be attached to a metal lined wall or set on a metal lined floor there will be a vibration set up in the metal, which will cause a more or less loud buzzing sound. The manufacturer recommends that fairly hard cored carbons be used in connection with this device, both top and bottom. The tap connection giving the highest amperage is the one opposite the tube connector.

If a dissolver is to be used with one economy coil the two lamps must be wired in series. See "The Stereopticon."

When using the economizer do *not* add rheostats to the circuit, or switches for regulating, or other devices. Schemes of this kind often cause a great deal of trouble, for which the instrument gets the blame.

The economizer is a very sturdily built, rugged device, which ought to last indefinitely if given reasonable care. It is well insulated and will not "bake out," owing to the extra heavy insulation between the core and winding, as well as between the layers.

THE FORMOSTAT

The formostat, which is widely used and well liked on the Pacific Coast, and somewhat known throughout the Middle West, is of the auto type of transformer. Its ratio is two to one for 110 volt current and 4 to 1 in the 220 volt type—that is

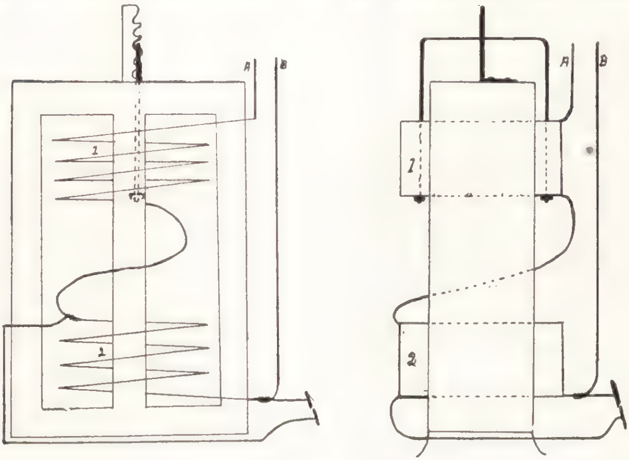


Figure 176.

to say, one ampere taken from 110 volt line becomes two on the secondary, while one ampere taken from the 220 volt line becomes four on the secondary. Its range of adjustment is from 30 to 65 amperes, and its construction is quite simple, there being two wires for the line and two for the lamp. These leads are marked with paper tags, when the formostat

is purchased. In case the tags are absent the two large leads should be connected to the lamp and the two smaller one to the feed wires. The adjustment is made in divisions of about 4 amperes and without in any way disturbing the arc.

In Fig. 176 we see a sectional front and side view, A and B being the line wires and 1 and 2 the coils. The regulation of amperage is secured by raising or lowering the top coil.

In Fig. 177 we have a view of the formostat. At the top is a notched rack upon which hangs a wire loop; from this loop is suspended coil 1, Fig. 176. By lowering coil 1, or in other words, dropping the wire loop to a lower notch in the rack, amperage is increased, or by raising it the amperage is lowered. The winding on the 110 volt formostat is of No. 5 wire, and as the instrument is of the auto type this is equivalent to two No. 5 wires in parallel, so that in fact each No. 5 wire has only to carry 32½ amperes. In the 220 volt type the winding is of No. 4 and No. 8 wires, and at full load the No. 4 carries 43 and the No. 8 17 amperes, respectively. A 110 volt formostat works well on any voltage from 105 to 125 and the 220 volt machine operates successfully at from 210 to 240 volts. The makers recommend that the formostat be placed on the floor under the lamphouse. Connect the wires marked "line," which are the smaller of the four wires, to the line through 30 ampere fuse and switch. Connect the two leads marked "lamp" directly to the lamp. The formostat makers recommend that there be no switch between the formostat and the lamp, but that it be placed on the line side. All wire connections should be soldered, unless some good type of wire connector is used; see D, Figure 30, Page 89.

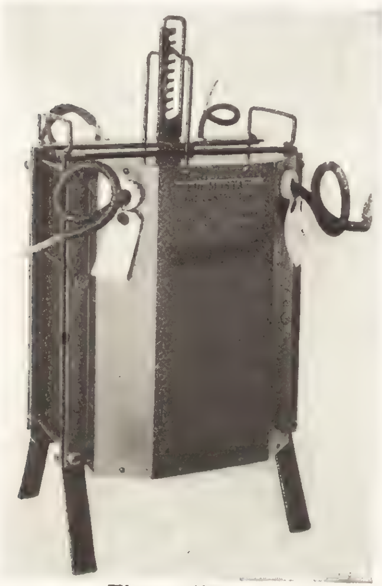


Figure 177.

Wiring Diagrams for the Formostat.—Fig. 178, No. 1, shows the connections used with the regular 110 volt formostat supplying two lamps alternately. No. 2 shows connections used with 110 volt formostat for three lamps. That is to

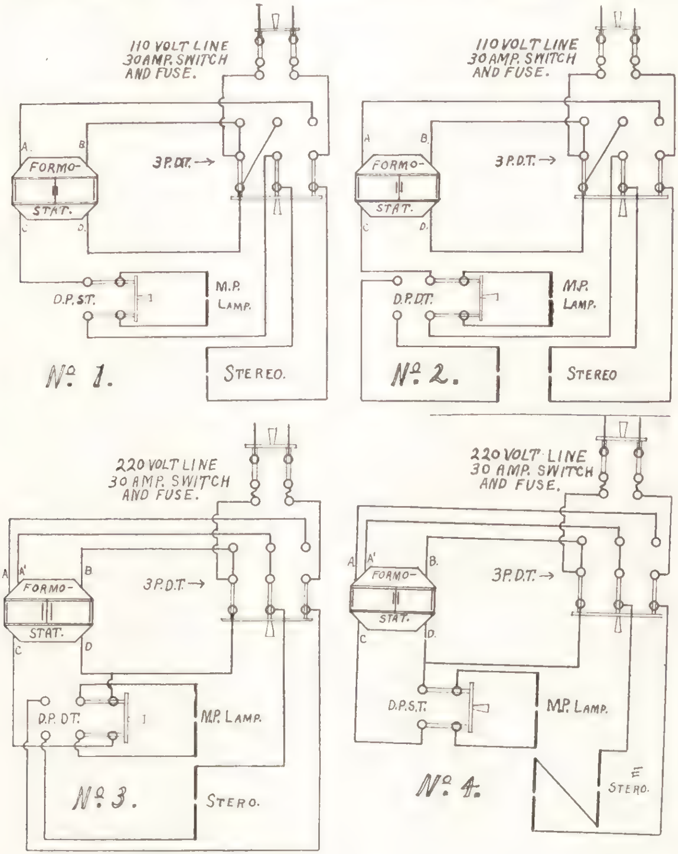


Figure 178.

say, a motion picture arc and a dissolver. No. 3 shows connections used with special 220 volt formostat for two lamps, and No. 4 shows connections used with special 220 volt formostat for three lamps.

The tags on the wires are marked A, B, C and D, in the 110 volt type, and AA prime, B, C, D, on the 220 volt tags. If it is desired to use the 110 volt formostat with connections as per No. 1 and 2, Fig. 178, the leads will first have to be selected by testing between the line and lamp leads with 110 volt lamp. Between two of these wires will be found no voltage and these wires are line A and lamp C, therefore the two remaining are line B and lamp D. This test must, of course, be made with the current on. If it is desired to use connections No. 3 or No. 4, Fig. 178, with the 220 volt formostat, put out before the beginning of 1912, the wires will have to be changed, and this the manufacturer will do, free of charge. The change cannot be made outside of the manufacturer's shop, and should not be attempted.

Motor Generator Sets

General Instructions.—There are certain instructions which apply alike to all motor generator sets, rotary converters and other devices of like nature. To incorporate these instructions in the matter covering each individual set would consume valuable space needlessly, therefore, they have been incorporated under the head of General Instructions.

General Instruction No. 1.—Locating the Motor Generator. In locating a motor generator or rotary converter, several things must be taken into careful consideration. Wherever practical it is much better to locate the machine either in the operating room or a room directly adjoining and connecting therewith.

A basement, particularly if damp or dark, is objectionable for installations of this kind. Where there is dampness the insulation of the wires will absorb more or less moisture, which will be expelled rapidly when the machine warms up, and this, many times repeated, is likely to produce injurious results. The most serious objection is that in case anything goes wrong it takes much longer to investigate and make the repair, if a repair is possible, than it would if the machine were located in or adjoining the operating room. Still another objection to basement locating lies in the fact that basements are usually more or less dark, which entails the making of repairs and performing other operations entirely by artificial light.

The only legitimate objection to locating machines of this kind in or adjoining the operating room lies in the possible vibration and noise or the weakness of the floor.

As a general proposition it may be said that any floor too weak to carry a machine of this kind is unfit to be the floor of an operating room. Vibration can be, to all intents and purposes, eliminated by means of felt, as per instructions under "Installation."

When practical, always set your motor generator out far enough from the wall so that you can walk all around it, and before your floor is put down have the conduits laid, so as to carry the connecting wires underneath the floor. This is a little extra expense and labor, but in the long run it pays, and pays big.

If you do locate your generator in the basement it is a good plan to place it on a pedestal or platform raised some distance from the floor, particularly if there is any danger of the basement at any time containing water. The frame of the machine should be thoroughly grounded by means of a copper wire, one end of which must make good electrical contact with the frame and the other with a water pipe or the earth, as described under "Grounds," Page 259. Also select as light a spot as possible, if any daylight enters the basement.

If the machine is located in the basement, make your operating room leads of ample size. It won't cost much more, and there will be less waste. The size of the leads will, of course, depend on the amperage they are to carry, and their length. In this connection see Pages 42 and 45.

General Instruction No. 2.—Installation. As soon as a new machine is unboxed, the name plate should be carefully inspected. If it be a D. C. to D. C. machine, you have only to ascertain that the volts marked on the motor name plate correspond with your line voltage. If it be an A. C. to D. C. machine, then the volts, cycles and phase must agree with those of the circuit on which it is to be used. The name plate marking will also indicate the volts and amperes for the arc lamp, and due care should be taken that the amperage rating, as indicated by the name plate, be not exceeded to any considerable extent, except for short periods of time.

If the motor generator is mounted on a sub-base which it is, for any reason, necessary to dispense with, great care must be exercised that the motor and generator be perfectly

lined with each other, else there will be undue strain on the coupling of the two shafts. Failure to perfectly line the shafts will probably result in noise, vibration and a rapid wear at both the coupling and bearings. Machines in which the armature of the motor and generator are mounted on one shaft, with but three bearings, and no coupling between, should never under any circumstances be installed without their sub-base, if they are of the type that uses a sub-base.

Where a motor and generator are locked together, on a sub-base or otherwise, it is not necessary to bolt them down solidly to the floor (it is not necessary to build foundations for machines of this character), and if the machine is located in the operating room or in an adjoining room it is not desirable to do so. The best plan is: Have a sheet metal pan made, one to two inches deep and sufficiently large to contain the base of the machine and extend out under the oil boxes. Procure heavy felt—the kind that is from one-half inch to one inch thick, if you can get it, and cut enough to make a pile at least 4 inches thick, cutting the pieces about 3 inches larger than the base of the machine. Place the felt where you propose to locate the machine, lay the pan on top of it and set the machine in the pan. No bolts or fastenings of any kind are necessary. If the machine does not set on the felt without giving trouble the armatures are not properly balanced and the machine should go back to the factory. The idea of the felt is to absorb all the vibration and prevent its being communicated to the floor and the walls of the building. *It renders the machine to all intents and purposes noiseless.*

Caution.—Where direct connected motors and generators are joined to each other by a flexible connection on the shaft, and *not* placed on a single, rigid iron base, then the pad proposition does not, of course, apply. Such an outfit must be bolted down on a solid foundation. After the machine has been on the pad a week, carefully level it, if necessary, by slipping sheets of metal under the low side. *It is very necessary that the armature be perfectly level endwise, else it will not "float"* (have end play), and failure to float will probably produce grooved bearings and commutator.

Having the machine located, revolve the armature by hand to make sure it revolves freely. Examine the armature and commutator carefully to see that they are not bruised. Let the oil out of the oil wells and fill them up with fresh oil. (See General Instruction No. 3.) The electrical connections

should be made by an electrician, who should follow the wiring diagram sent with the machine.

General Instruction No. 3.—Oil. The much advertised patent oils are absolutely unfit for motor or generator lubrication. If you use them you are more than likely to either have trouble with the bearings, or a comparatively frequent and unecessary expense for bearing renewal, to say nothing of worn journals.

The character of oil to be used will depend considerably upon climatic conditions. In the South, where it is always comparatively warm and much of the time summer heat, I would recommend the same oil used for generators in the local electric light plant. The superintendent of the plant will tell you what it is, and no doubt will sell you oil at a reasonable figure. You cannot do any better, because oil used to lubricate heavy generator bearings is necessarily an excellent lubricant, and you can rest assured the light plant has the oil best suited to local climate. In the Middle North, I would recommend a medium heavy dynamo oil for summer use; it may be used the year round if the generator is in a room that is kept warm in winter, but if in an unheated place a light dynamo oil will be found to give the best satisfaction in winter. In the extreme North a medium oil in summer and a light dynamo oil in winter will be best.

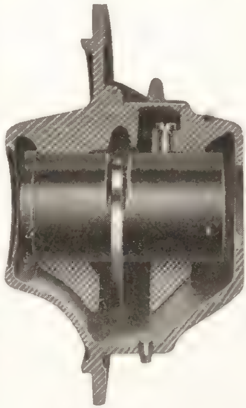


Figure 179.

Caution.—Most, if not all, motor generator sets have the oil carried up to the journals by rings which rest on the journals and revolve merely by the friction of their own weight on the journal, as per Fig. 179, which shows the oil ring resting on the journal, revolving through a groove in the babbit bearing. Now, you will readily see that if too heavy an oil be used in winter time, and the machine be located where it is very cold, the oil will congeal and stop the ring from revolving, in which case no oil would be fed to the journal and there would be trouble. There are grooves cut in the babbit bearing to facilitate oil distribution.

Be sure your oil is free from dust or sediment. Never leave oil standing open. If you do it will collect dust and

the lubricating quality of the oil will be very greatly impaired. Dirty oil is often the cause of bearings heating.

General Instruction No. 5.—Cleanliness. It is important that all parts of motor generators be kept scrupuluosly clean. Oil should not, under any circumstances, be allowed to collect, either on the machine or on the floor near it, and the machine should, so far as possible, be kept free from dust. A medium size hand bellows will be found very convenient for removing dust from the armature, from around the pole pieces and in other inaccessible places. *A dirty machine is evidence of a lazy, indifferent or incompetent operator.*

General Instruction No. 6.—Loose Connections. It is highly important that all electrical connections and all bolts and nuts be inspected periodically and carefully tightened up, and all electrical connections be kept not only tight but perfectly clean. Loose connections are a continual source of absolutely unnecessary trouble.

General Instruction No. 7.—Ammeter and Voltmeter. All motor generators are or should be provided with both voltmeters and ammeters, and *they should by all means be located on the wall in front of the operator as he sits in operating position.* It is a serious mistake to install a voltmeter and ammeter in an out of the way place. They should be constantly under the operator's eyes, since there are points at which the arc furnishes maximum illumination with minimum current consumption, and with the ammeter directly in front of him the operator soon learns where he gets the most light with the least current consumption and, if he is a capable man, keeps his arc at that point.

General Instruction No. 8.—Care of the Commutator. The commutator of a direct current motor or generator ought to require very little care, but sometimes does require a great deal.

The best evidence the commutator is in A1 condition is a sort of glazed appearance, smooth as glass, a brownish shade in color and a slight squeak from the carbon brushes when the armature is revolved slowly. To obtain and maintain this condition the following care must be given:

(a) The brushes kept set as nearly as possible at the sparkless point, which point may, with the old style generator lacking the inner or "commutator" pole, vary with the load. On the newer type of generator the inner or commu-

tating pole is used and the manufacturer marks the point at which the brush yoke should be set by making either a chisel or center-punch mark on the yoke and on the frame. Some manufacturers fill these marks with white paint so they are very easily seen—some do not. Where these marks are present the brush yoke should always be set so that the marks on the frame casting and the yoke coincide, or, in other words, are opposite each other.

(b) The brushes must have just sufficient tension to make good electrical contact with the commutator, *remembering that every particle of unnecessary pressure will tend to unduly wear both commutator and brushes,* and to groove the copper unless the armature has a little end play.

(c) That the commutator be kept clean and free from dust. This may best be accomplished by cleaning the whole machine every day, blowing the dust out from around the field poles, etc., with a bellows, and last of all, wiping off the commutator with a canvas pad made as follows: Cut a piece of ordinary canvas 6 inches square, fold this so that it is 2 inches wide by 6 inches long, which will form a pad with a face of one thickness, backed by two thicknesses. Next open up the pad and smear a little vaseline on the center section, which is the back side of the face of the pad, after which refold, let lie a few hours in a warm place, and it is ready for use. Sufficient vaseline will gradually soak through the pad to give the commutator all the lubrication it needs, and that is mighty little. The foregoing holds good in summer, and in winter, too, if the generator is located in a warm room, but if, on the other hand, the machine is cold, then it will be well to moisten the face of the pad by using a few drops of a very thin oil on a piece of glass, spreading it around evenly and then wiping it off on the face of the pad, the idea being to get the oil evenly distributed on the pad. Remember this, however, *too little lubrication is better than too much,* and heavy lubricants (thick oils) must never, *never,* NEVER be used on a commutator. If one application as above every six-hour run does not suffice, then it is likely that, (1) your brushes have too much tension, (2) your machine is overloaded, (3) your brushes not properly set or (4) there is some other trouble. *Never use gasoline or benzine around a commutator; it is likely to attack and soften the shellac and insulation and thus set up serious trouble.*

Caution.—Where the mica insulation of the commutator is undercut great care should be taken in regard to the lubricat-

ing of the commutator, and if a soft brush is used no lubrication should be given. This caution is necessary with undercut insulation by reason of the fact that the lubricating medium will have a tendency to combine with carbon dust and fill up the space between the commutator bars, thus in time possibly short circuiting the bars. Also where soft brushes are used the brushes themselves as a rule contain sufficient paraffine to provide all necessary lubrication.

(d) See to it that sufficient oil, or combined oil and carbon dust, has not collected at any point or spot, either on the commutator or face of any brush, to form a semi-insulation.

(e) That there are no high or low bars and that the commutator is perfectly round.

(f) That a fragment of copper does not drag across the insulation between two adjacent bars, or that oil and carbon dust does not form such a bridge. This fault will be evidenced by a thin, sparkling ring of light around the commutator.

(g) That the brush springs do not carry sufficient current to heat them.

(h) That the brushes fit properly in their holders, and *are kept free from accumulation of dirt, dust,* etc. They should be taken out and cleaned once in every 60 hours run.

(i) That the brushes are neither too hard nor too soft.

(j) That the armature "floats" slightly, i.e., has from one-sixteenth to one-eighth inch end play, according to size of machine. This tends to prevent the brushes from cutting grooves in the commutator; is *very important.* Unless the machine sets perfectly level the armature will not "float," hence a *level setting is important.*

(k) That the copper and mica insulation wear down evenly.

(1) That the generator is not overloaded, and that there are no other faults present which would tend to cause unnecessary sparking, or otherwise injure the commutator.

Should the brushes of the motor or generator show excessive sparking, it might be attributed to one of the following causes;

(a) If a belt driven machine, the belt may be slipping; if the sparking is spasmodic or intermittent, the trouble will probably be found in the belt, since belt slip causes sudden

variations in speed, and this will, in itself, cause sparking, since it has the effect of producing heavy fluctuations in the voltage. The remedy, of course, is to tighten the belt, or use a belt dressing, and, in this connection, ordinary black printer's ink is as good an article as I know of to stop belt slipping, and ten cents worth obtained at any printer's will last for a month or more.

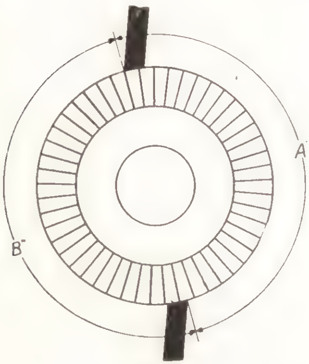


Plate 1.

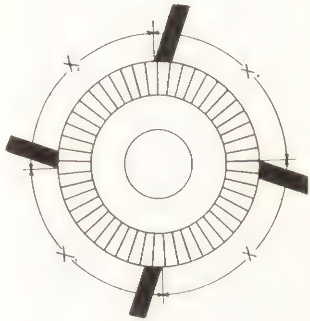


Plate 2.

Figur 180.

(b) Brushes not set correctly, that is to say, the rocker arm too far one way or another; also the brushes may be too close together or too far apart. In the first case the remedy is to move the rocker arm until the neutral position is found, whereupon sparking will either cease or be reduced to a negligible quantity. If this fails to remove the trouble I would then see if the brushes themselves are the correct distance from each other. In a two-pole machine they should bear on the commutator at diametrically opposite points. That is to say, the distance from brush-point to brush-point should be exactly the same when measured both ways around the commutator; in other words, distance A should equal distance B, as per 1, Fig. 180. If it be a four-pole machine with two positive and two negative brushes (four altogether) the correct distance to set them is one-fourth of the circumference of the commutator between the points of adjacent brushes, that is, distances marked X should all be equal, as per 2, Fig. 180. If it be a machine with more than two positive and two negative brushes (more than

four brushes all told), divide the number of commutator segments by the number of poles, or field coils of the machine; the result will equal the distance, in commutator bars, the brushes should be apart.

(c) Dirty brushes or dirty commutator may cause sparking, and may even prevent the generator from picking up its load at starting, and will sometimes cause a badly fluctuating arc. Some of the causes of dirty brushes and dirty commutator are as follows: Carbon brushes contain a small amount of paraffine. When the carbon gets warm this paraffine, if excessive in quantity, is likely to ooze out and coat the commutator, thus partially insulating it in spots, or the paraffine may mix with dust and coat the end of the brush with a semi-insulating compound. If copper brushes be used they may become clogged with a mixture of oil and dust; the obvious remedy is to clean the dirty parts. To clean the commutator, use a brush stiff enough to remove any foreign matter which may cling to the surface of the commutator, yet not stiff enough to injure the surface. If the brush will not remove the deposit, then use 00 sand paper (*never use emery paper or emery cloth on a commutator*) applying the same while the commutator is revolving, but with just barely enough pressure to clean the metal. After having cleaned the surface, put a few drops of light oil on a cloth, or use the pad already described and hold it lightly to the commutator as it revolves. Don't get much oil on the surface of the commutator—just a "suspicion," as it were. If it is a carbon brush which is dirty, or which does not fit the curve of the commutator, raise it just enough to slip a piece of fine sand paper (½ or No. 1) between the brush and commutator, with the sand side against the brush, and pull it back and forth around the curve of the commutator until enough of the brush has been ground away to clean the surface, or to make it fit the commutator. *Be sure and always clean the commutator thoroughly after doing this,* since if carbon dust is left adhering to its surface it may work into the insulation and cause a local short circuit between two bars. If the brush is made of metal take it out and clean it thoroughly with gasoline, trimming the edges and corners off with a file if necessary.

(d) The brush not making proper contact with the commutator, which may be due to (1) tension spring not being strong enough; (2) tension spring having lost its temper; (3) brush stuck in its holder; (4) brush not fitting the curve

of the surface of the commutator; (5) brush holder set at the wrong angle; (6) high bar or insulation. The remedies are: (1) Stretch the spring, if it is a spiral spring, or if it is not a spiral spring, do whatever is needful to make the spring stronger, installing a new one, if necessary; (2) put in a new spring, and, since the fact that the old spring has lost its temper is evidence that the spring itself is carrying too much current, reinforce it with a current-carrying jumper; (3) the remedy is obvious: do whatever is needed to loosen the brush; (4) use sand paper, as before described, until the brush fits the commutator surface; (5) straighten the holder; (6) see section f, further on.

There should, however, be only sufficient tension on the brush to insure its making good contact with the commutator. Be careful, therefore, and don't get your springs *too* strong. If you do there will be unnecessary wear both on the brush and the commutator, and this will to some extent add the element of mechanical heat generated by undue friction.

The reasons for the brush sticking in the holder are: (1) Dirt in the holder or on the brush; (2) brush not true; (3) hammer that rests on the brush (where this type of tension is used) not working true on the slot-end of the brush. The brush should slip freely in its holder, though not freely enough to allow of any considerable amount of play, and the hammer should be so adjusted that it lies true in the slot at the end of the brush. A brush which is not true may be evened up by tacking No. 1 sand paper on a perfectly flat surface and rubbing the brush thereon.

(e) Commutator worn too thin. If the commutator wears down too much, although it may wear evenly and appear to be in good condition, the brushes will spark in spite of everthing you may do, particularly when the machine is working at capacity. The reason might lie in the fact that since the segments are wedge shape, as they wear down they become narrower, thus allowing the brush to span more of the circumference of the commutator than was intended, or there might be a slight error in the setting of the brush holder, and this error becomes greater as the distance between the brush holder and the commutator increases. The only remedy is a new commutator, but the sparking may possibly be lessened somewhat by moving the brush holder closer to the commutator. This trouble appears at its worst in a series type machine.

(f) A high or low commutator segment. This fault may

usually be detected by the clicking sound made by the brush in passing over the defective segment. When the segment is low the brush rides in toward the shaft each time the bad bar passes under it. If it is high the brush will jump. The remedy will depend somewhat upon the cause. It may be that the segment has become loose, in which case the bar may be driven back into place by tapping lightly with a wooden mallet, or by using a wooden block and hammering gently, but the armature will probably have to be taken out and sent to the repair shop, unless you yourself can tighten the clamp ring—a rather delicate operation. If the segment is high by reason of the fact that, being of harder material than its mates it has worn down more slowly, then, using a fine file it may, with great care, be dressed down. If, on the other hand, it is low, then the only remedy is to turn down the rest of the bars to match. If the fault is slight this may be done by removing the brushes and holding a piece of grindstone which has been turned out to fit the circumference of the commutator to it while it is revolved rapidly. This process is, however, slow. The best way is to put the armature in a lathe and turn it off. The grinding may, in the case of a motor, however, be done with the brushes down and the machine running by its own power, but if this is done it should be done with great caution. When you are through the face of the brushes should be thoroughly cleaned by drawing No. ½ sand paper around the curve of the commutator with the sand side next to the brushes in order to grind off their face, and thus remove any particles of sand which may have become embedded in the brush, since it would scratch the commutator and cause undue wear. It is better to do the grinding with the brushes raised and the machine run from some outside source of power where it is practicable.

(g) A rough or eccentric commutator. This may be caused by improper care, or by the use of defective materials in its construction. A rough commutator may be detected merely by feeling. The mica insulation between the segments will either stand out in ridges, or be worn down so that there is a small groove between the segments. An eccentric commutator may most readily be detected by holding some instruments firmly against the frame opposite the commutator, so that its ends just touch the bars. If the commutator is true it will touch all the way round as the armature is slowly revolved, but if the commutator is eccentric it will, of course, only touch the high spots. If the eccentric

be bad it will cause the brushes to move in and out of their holders perceptibly when the armature is revolved slowly. The only remedy is to turn the commutator down, and this can only be sucessfully done in a machine shop where work of this character is understood.

(h) Brushes having too high resistance, the evidence of which is that they get very hot and slowly crumble away at the end next to the commutator. The remedy is to get good brushes.

(i) Low bearings. In some types of machines low bearings will throw armature out of center sufficiently to distort the magnetic field, and this will cause sparking. The evidence of this fault is that the air gap between the armature and the pole piece will be smaller at the botttom than at the top. The only remedy it to replace the worn bearings with new ones.

(j) A short-circuited armature coil. This trouble will cause the voltmeter to fluctuate badly, and the shorted coil to heat very quickly. The coil may be shorted within itself, or there may be a connection between two adjoining commutator segments. Remedy: locate and remove the short.

(k) A reversed armature coil. This may be located by holding a compass over each coil of the armature in turn, and sending a direct current through the coil, with the brushes raised and resistance in series; or current from a battery may be used. The coil which causes the compass to turn in the opposite direction from its mates is the guilty party. The remedy is, reverse the connection or direction of the windings of the defective coil.

(1) A bent armature shaft. This, of course, will cause the whole armature to wobble. The only practical remedy is a new shaft.

(m) Overload. The most prominent symptom of overload is the armature heating all over. Sparking may be lessened, but not entirely stopped, by moving the brushes ahead or back. By "ahead" I mean in the direction in which the armature is revolving. The remedy is obvious. Get a machine of larger capacity, or cut down the load on the one you have.

(n) High speed sparking is caused by the brushes not being able to make proper connection with the commutator by reason of excessive armature speed.

(o) A weak field. This may be detected in a generator by its inability to pick up readily, and by failure to maintain normal voltage. On a motor the starting power is decreased,

but the speed and current are increased. A weak field may be caused by (1) a loose joint in the magnetic circuit; (2) heat may lower the insulation of the field winding sufficiently to allow the current to short circuit through it; (3) there may be a metallic short in the field coil. Remedies: With a voltmeter test across each field coil; the one showing the least drop is the defective one. If all read the same, then there is a loose joint in the magnetic circuit.

(p) A shaky foundation, or anything else that causes vibration in the machine will set up commutator sparking. The only remedy is to eliminate the vibration.

Should a ring of fire develop, or something that *look*s like a ring of fire, around the commutator, it may be caused by (a) a piece of copper pulled across the insulation between two bars: (b) an open circuit in the armature.

In the first instance the ring will not be strong, but just a thin sparkling streak of light around the commutator. The remedy is to remove whatever is causing the short between the bars, which can usually be done by holding a piece of fine sand paper lightly to the commutator, though the right way is to stop the machine and hunt up the trouble, using a magnifying glass if necessary. An open circuit in the armature, however, might be caused by reason of a break in one of the armature wires itself, or in one of its connections with the commutator, and these in turn may be caused by excessive current burning off one of the wires, or a nick in one of the wires may be the seat of the trouble, or the commutator may become loosened and break off one or more of the leads. The defect may be readily located, as the mica will be eaten away from between the commutator segments to which the faulty coil is connected, and the segments themselves will become full of holes and burned at the edges. If this trouble is caught in time the open may be closed and the commutator turned up true. Sometimes, by reason of carlessness, abuse or overload, the armature becomes hot, and this causes the solder on the connections between the coils and commutator bars to soften, whereupon centrifugal force will throw it out, and there will, of course, be trouble, though there is no complete opening of circuits. The action, however, so far as the ring of fire be concerned, is the same as if there were, and the commutator bars will become blackened and pitted and their edges burned. But if any of the foregoing faults be caught in time they can be remedied; if not it will be necessary to

install a new commutator, and perhaps a new armature coil as well.

General Instruction No. 9.—Before starting the machine see that it is perfectly clean and that the brushes move freely in their holders and make good contact with the commutator. Also make sure that all connections are tight.

General Instruction No. 10.—Bearings Run Hot. The first rule when a bearing runs hot is to see that the oil well is filled with good clean oil and that the oil-rings run freely, carrying the oil to the shaft. If the bearing runs hot on a new machine shut down and wash out the bearing with kerosense. Trouble is probably due to dirt that has accumulated in shipment. If the bearing has been running along satisfactorily and suddenly gets hot, flood the well with clean oil, leaving the drain cock open and pouring in the clean oil while the machine is running to free the bearing from dirt. A change to a different grade of oil, either heavier or lighter, will often correct a bearing trouble of this kind. NEVER USE WATER TO COOL A BEARING, it may get into the insulation of the windings and cause a worse trouble. A machine with clean oil of the proper grade never gives trouble from hot bearings.

General Instruction No. 11.—Heating. Many operators who are handling motor generator sets and find them getting rather warm become unduly alarmed. Excessive heat is, of course, not only bad, but dangerous to the insulation. However the fact must be taken into consideration that the temperature of operating rooms frequently reaches between 35 and 40 degrees Cent. The American Institute of Electrical Engineers allows a temperature rise of 50 degrees Cent. (90 degrees Fahr.) above surrounding atmosphere, this being based on 40 degrees (72 degrees Fahr.) atmospheric temperature. Therefore, simply because, in a hot operating room one cannot hold his hand on the iron of the machine with comfort, it does not follow that the temperature is dangerous. *A thermometer ought always to be used to determine such matters.* If the thermometer does not register a temperature rise of say more than 30 or 35 degrees above the surrounding atmosphere (Centigrade), you need have no uneasiness. To change Centigrade temperature to Fahrenheit temperature multiply the degrees Cent. by 9/5 and add 32. For instance: operating room temperature, 40 Cent. What is it Fahr.? $40 \times 9/5 = 40 \div 5 = 8 \times 9 = 72 + 32 = 104$ degrees Fahr.

FORT WAYNE A. C. TO D. C. AND D. C. TO D. C. COMPENSARCS

General Description.—Both A. C. to D. C. and D. C. to D. C. compensarcs are what are commonly styled "motor generator sets," that is to say, two machines coupled together, one being a motor and the other a generator. In the A. C. to D. C. compensarcs the motor and generator are mounted on a common base, as shown in Plate No. 1. Fig. 181. The motor and generator frames of the D. C. to D. C. compensarcs are, however, coupled together by a common flange, as shown in Plate No. 2, Fig. 181, so that no base is necessary. All Fort Wayne compensarcs are shipped completely assembled, and require only proper installation, filling of the bearings with oil and proper electrical connection to the supply and lamp circuits (See General Instruction No. 2, Page 369) before putting into service.

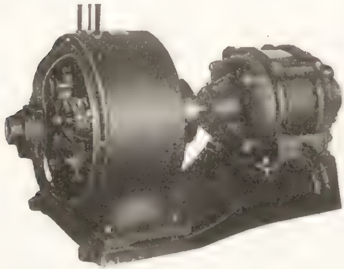


Plate 1.

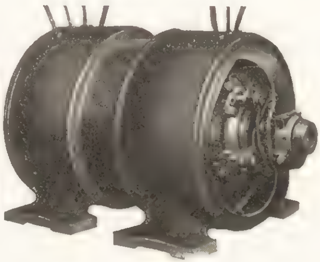


Plate 2.

Figure 181.

The A. C. to D. C. compensarc consists of a standard induction motor, either single, two or three phase, the same being directly connected to a special D. C. generator. The armature shafts of the set are joined by couplings, and there are but three bearings, two on the motor and one on the generator. The generator end of this set is wound specially for use with projection arc lamps, and the winding is such that no steadying resistance is necessary between the arc and generator.

While the 115 and 220 volt D. C. compensarcs are commonly referred to as "motor generator sets," rightly speaking they are not, since electrical connections are different from the true motor generator set. The machine is in effect a

"balancer." The 500 volt D. C. compensarc is, however, a true motor generator, the motor having no electrical connection with the generator. The generator end of the D. C. compensarc has exactly the same characteristics as that of the A. C. to D. C. machine, and will handle the arc without any steadying resistance interposed. The two-lamp outfits use a steadying resistance *during the time of changing from one lamp to the other only,* during which period both arcs are burning simultaneously. The generator end of both A. C. to D. C. and D. C. to D. C. compensarcs have practically the same mechancial construction.

The D. C. compensarc has a fan, protected by a metal guard for the safety of the operator, mounted on the shaft between the two machines. This fan rotates with the shaft and sets up a current of air which helps keep both motor and generator cool.

Installation.—See General Instruction No. 2.

Oil.—See General Instruction No. 3.

Removing Sub-Base to Install.—See General Instruction No. 2 and, in addition, dowel pins are provided in the base of the generator end. To remove these pins hold the squared head of the pin with a wrench and tighten up the nut, which will pull out the pin. Be very careful that any liners found under the feet of the motor or generator be carefully replaced in their original position. Should the coupling be taken apart it must be very carefully reassembled, *making sure that the chisel marks on the rim register with each other.*

A. C. to D. C. compensarcs should never be run on circuits where the variation of either frequency or voltage from normal exceeds 5 *per cent. Where both frequency and voltage vary the sum of the variation must not exceed* 8 *per cent.*

Size of Fuses.—The lamp side of these machines does not require fusing, since the generators automatically protect themselves against overload current when the arc is short circuited.

The motor side of the various machines should be fused as follows:

D. C. Compensarcs.

35 amp. 1-lamp	50 amp. 1-lamp and 2-35 amp. lamps alternately	2-50 amp. lamps alternately
115 volt—30 amp. fuses	60 amp. fuses	100 amp. fuses
230 volt—20 amp. fuses	40 amp. fuses	60 amp. fuses
550 volt—10 amp. fuses	20 amp. fuses	30 amp. fuses

A. C. Compensarcs.

	35 amp. 1-lamp	50 amp. 1-lamp and 2-35 amp. lamps alternately	2-50 amp. lamps alternately
Single Phase 110 volt	35 amp. fuses	80 amp. fuses	125 amp. fuses
Single phase 220 volt	20 amp. fuses	40 amp. fuses	60 amp. fuses
Two-phase 110 volt	20 amp. fuses	40 amp. fuses	60 amp. fuses
Two-phase 220 volt	10 amp. fuses	20 amp. fuses	30 amp. fuses
Three-phase 110 volt	20 amp. fuses	50 amp. fuses	50 amp. fuses
Three-phase 220 volt	12 amp. fuses	25 amp. fuses	30 amp. fuses

The wires should be of sufficient size so that the line drop from the machine to the lamp will not exceed one

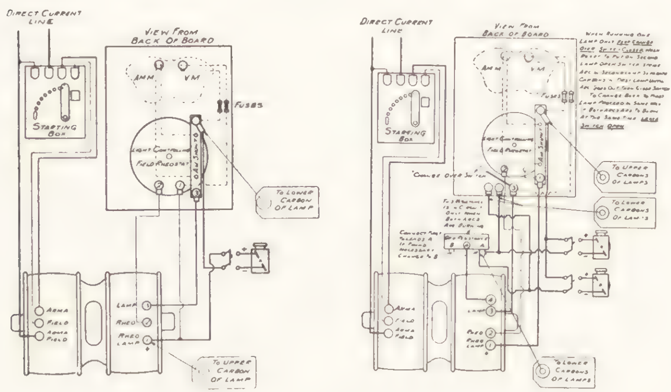


Plate 3. Plate 4.

Figure 182.

volt (see Page 45) or 2 per cent. of the voltage when the machine is delivering full load current to the lamp. If wires of too small diameter be used the lamp will be robbed of some of its amperage and give poor light.

Electrical Connections.—The D. C. to D. C. Compensarcs for 115, 230 and 500 volts, one lamp outfits, are connected as shown in Plate No. 3, Fig. 182, while those for the two lamp outfits are connected as shown in Plate No. 4, Fig.

182. The connections for the A. C. to D. C. two lamp compensarc is shown in Plate No. 9, Fig. 183, while those for the one lamp outfits are connected as shown in Plate No. 8, Fig. 183.

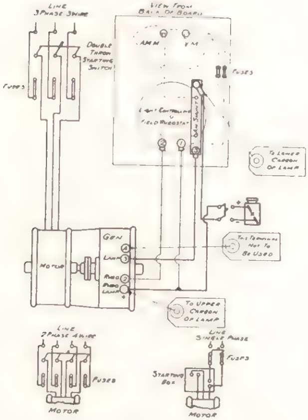


Plate 8.

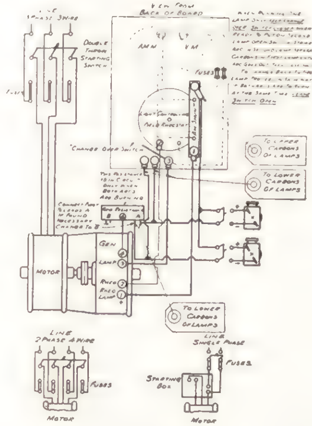


Plate 9.

Figure 183.

Internal Connection Diagram, 115-230 Volt D. C. to D. C. Compensarc.

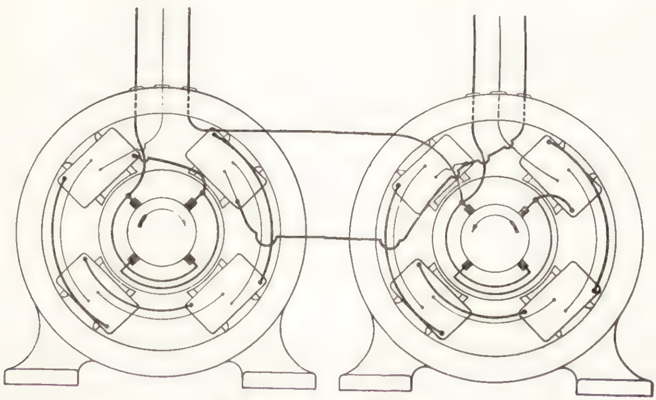
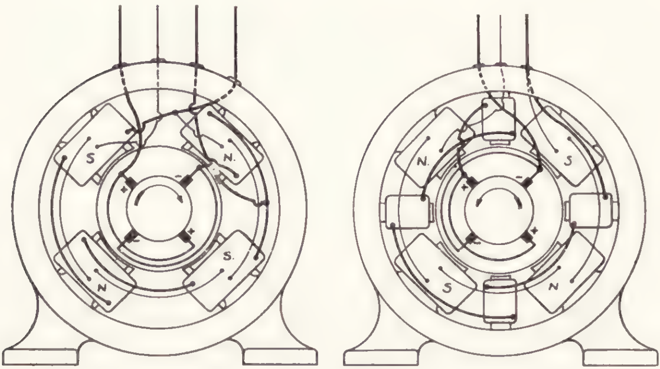


Plate 12, Figure 184.

The diagrams shown in Plates 3, 4, 8, and 9, which are the external connections for the different types of compensarcs, are practically the only ones the operator will have occasion to refer to, since all internal connections are carefully made before the machine is tested at the factory, and are as they should be when the operator receives the machine.



Internal Connection Diagram, 500 Volt D. C. to D. C. Compensarc.

Plate 5, Figure 185.

It is only in exceptional cases that some trouble inside the machine necessitates the opening of the internal connections. In such cases Plates 5, 6, 7, and 12 should be referred to in reconnecting.

It is recommended that one of the steel panel switchboards, Plate 10, especially designed for use with the compensarc, be included in each compensarc installation. It will not only facilitate the wiring of the set, but help serve the purpose of General Instruction No. 7, which see.

Starting D. C. to D. C. Compensarcs.—To start the D. C. to D. C. compensarc, with projection machine switch open, close the switch in the main line, whereupon armature will begin to slowly rotate, in a *counter-clockwise* direction as you face the generator commutator. *Proper direction of rotation is indicated by the small arrow on the bearing housing.*

Next move lever of starting box slowly to right as machine speeds up, until it finally reaches the last contact, where it will be caught and held by the cut-out magnet. By this time the armature will have reached maximum speed.

The field rheostat of the generator field circuit is marked with a small white arrow to indicate proper position it should occupy for machine to deliver the current and voltage at the arc as shown on generator name plate.

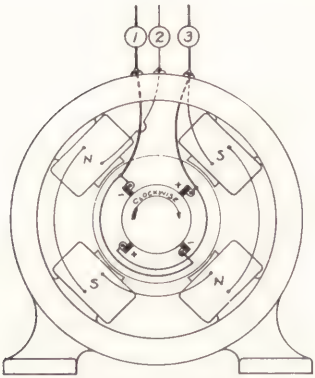
To Start Arc.—When the armature is up to speed, arc may be struck as follows: Close projection machine switch and bring carbons of lamp together, *instantly* separating them again about one-sixteenth of an inch, gradually increasing this distance as the carbons heat up until the proper length of arc to supply maximum screen illumination is reached, whereupon the voltmeter should register about 55 volts at the arc and the ammeter about 35 amperes, where the 35 ampere set is used, or 55 volts at the arc and 50 amperes if it is a 50 ampere outfit.

Caution.—*The closing of the carbons short circuits the generator, and, of course, instantly creates an overload. The generator is wound to protect itself against this very thing, and unless the carbons are instantly separated the generator will lose its voltage. This does no harm to the machine, but it will be necessary to separate the carbons for perhaps ten seconds until the voltage again reaches normal, whereupon the arc may be struck in the usual manner.*

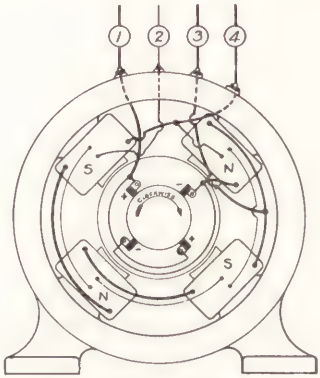
As the machine warms up it may be necessary to move the handle of the rheostat one or two buttons away from the mark, to the left, in order to maintain the desired voltage and amperage at the arc.

Reversing Connections.—Provided the circuits have been connected as shown in the diagram the polarity will be as indicated, and the upper carbon of the lamp will be positive. Should an error be made in connections, and either or both the voltmeter and ammeter read backward, the trouble must be corrected. Examine all diagrams and see that all connections are made in accordance therewith, particularly that the motor terminals are connected to the proper side of the line. *Do not attempt to correct trouble by reversing the terminals at the generator.* The machines are all carefully checked up complete with their equipment when tested, and

the motor must, therefore, be connected to the proper side of the line in order to bring the polarity of the voltmeter and ammeter of the projection lamp right.



One-Lamp Outfit.
Plate 6.



Two-Lamp Outfit.
Plate 7.

Internal Connection Diagram A. C. to D. C. Compensarcs.

Figure 186.

The operation of the two-lamp-alternately equipment is the same as for the two-lamp-alternately A. C. to D. C. compensarc.

Starting A. C. to D. C. Compensarcs.—In starting A. C. to D. C. compensarcs, see that the projection lamp switch is open. If the motor is single phase, close the main line switch and move the starting box arm from "off" position to the split segment, which will put into action the number of starting coils necessary to cause the armature to rotate. When the armature has attained nearly full speed, the arm of the starting box should be moved quickly over to the last segment where it is held by a latch controlled by a relay magnet. Should the voltage at any time fail, the relay magnet will release the latch, allowing the starting arm to automatically return to the "off" position, thus protecting the motor armature from damage in case the voltage comes on again.

The two and three phase outfits do not require starting boxes, but should be equipped with double-throw starting switches which have only one side fused. When starting up the switch should first be closed to the unfused side. When the speed of the armature reaches normal the switch should be quickly thrown over to the running (fused) side. When the

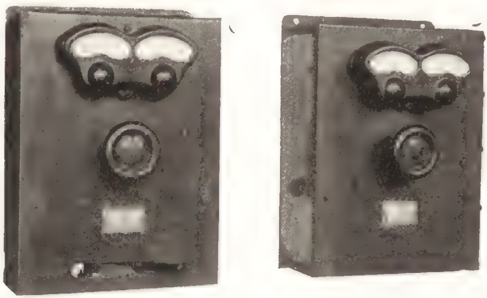


Plate 10, Figure 187.

speed of the motor reaches normal, the starting box handle or the double-throw switch in running position, and the rheostat handle set as indicated by the white arrow, the projection machine switch may be closed and the arc struck as described under "Starting D. C. Compensarcs."

The coupling between the motor and generator is marked to show the direction in which the armature should revolve. It should run *clockwise* as one faces the generator commutator. The direction of rotation of two-phase induction motors may be reversed by interchanging the two stator leads of the same phase. In the case of single or three phase motors it is only necessary to interchange any two leads.

Operating Directions for Two-Lamp Outfits, both D. C. to D. C. and A. C. to D. C.—The motor of the two lamp outfits is started the same as the regular single-lamp outfits, directions for which have already been given.

Have change-over switch (by change-over switch the single pole double contact switch is meant) on the panel closed, and start the first lamp by closing the switch and striking the arc in the usual manner. When it is desired to change from one lamp to the other, open change-over switch while the first lamp is still burning, then close the

projection machine switch of the second lamp and strike its arc. Open the projection machine switch at the lamp which is to be cut out, and then close the change-over switch. By tracing the connections in Fig. 182 and Plate 9 it will be seen that when the change-over switch is opened the current must flow to the lamp which is burning, and must pass through grid resistance, which has the effect of steadying the arc and preventing it from going out at the instant the arc is struck at the second lamp. It is therefore possible to strike the second arc and burn the crater into proper shape while the end of the first reel is still being projected, and to accomplish the effect of dissolving one picture into the next. The steadying resistance is only in circuit when both lamps are burning, and care must be taken that the change-over switch is kept closed when only one lamp is burning. If, for any reason, an increase in current is needed at the arc, or it is necessary to heat up the carbons very quickly, the change-over switch may be opened on one lamp for a few minutes, thus increasing the current in the arc without disturbing the field rheostat setting.

Caution..—*Keep the first arc rather short at the instant the second arc is struck.*

If this is done neither arc will go out, or even flutter during the period of lighting the other arc. The ability to handle both arcs perfectly and change over without a flicker in the picture is soon acquired, and if the second arc is started long enough ahead to be perfectly steady there is no difficulty in dissolving one picture into the next sucessfully.

Caution.—*Care must be taken that the two lamps are not burned longer than is really necessary, since the compensarc is not intended to carry both lamps continuously, neither has it the capacity to do so.*

With one lamp burning the ammeter will show from 35 to 50 amperes, and the voltmeter about 55 volts; when both lamps are burning the ammeter will show approximately 70 to 100 amperes and the voltmeter 70 to 75 volts, the voltage being automatically increased to compensate for the drop in the grid resistance. The voltmeter, as shown in the diagram, Plate 4, is connected across machine terminals 1 and 3 and indicates the machine voltage, which is the same as the arc voltage when the change-over switch is closed.

Care of Machine.—Cleanliness. See General Instruction No. 5.

Oil.—See General Instruction No. 3; also, in addition, immediately after starting a new outfit raise the bearing caps and see that the oil rings are revolving freely and carrying oil up to the top of the shaft. Keep the oil to the proper level in the well, which is nearly to the lip of the overflow oil gauge. The oil wells should be cleaned out occasionally and new oil supplied. They should invariably be filled through the side filling hole and *not* through the top of the bearing. If filled through the top the oil is likely to run out through the ends of bearings, get into the windings and do damage.

Bearings.—As soon as the bearing linings become worn so that the armature is in danger of rubbing against the stator, a new set of bearing linings must be inserted. To remove the bearings first take out the set screws in the bearing-housing. Having done this lift the oil rings up so that they clear the bearing lining; to lift rings use a wire with a hook bent on one end and raise rings with wire through the bearing cover and drive out the bearing linings with a wooden block of the same diameter as the bearings themselves. The bearings are so made that they fit the hole in the housing snugly enough to require light driving to seat them, and they must be handled carefully and intelligently. When duplicate bearings are supplied for the alternating current motor the set screw depression is already in the bearing, but the D. C. motor generator bearings, which regulate the end play, are supplied without the spot for the end of the set screw and they must be spotted before being put into place. Use a three-sixteenth inch drill and drill a spot for the tip of the set screw the *same distance from the end of the bearing as the one being replaced.*

Care of Commutator and Brushes.—See "General Instruction," No. 4, and in addition, to secure proper commutation and proper operation the brushes must occupy the correct position on the commutator. The proper position of the brush has been determined at the factory, and is indicated by chisel marks, filled with white lead, on the brush yoke and frame.

It is very important that these marks be in line with each other.

Should the brush holders become loosened or moved in any

way they must be carefully reset so that they may make proper angle with the commutator, as shown in Plate 11.

They must also be so placed around the commutator that the distance from tip to tip of the brushes is exactly the same when measured both ways around the commutator. See Fig. 180, Page 375. Care should be taken that the brush holder be securely fastened at an even height, one-sixteenth of an inch above the commutator. It is recommended that an extra set of brushes be kept on hand. Brushes may be worn down to approximately three-quarters of an inch in length. Only brushes of the proper grade will give satisfactory results, therefore only the brush furnished with the machine or others exactly the same grade should be used.

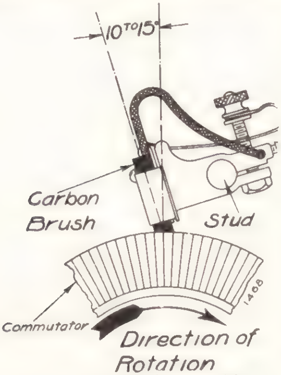


Plate 11, Figure 188.

Loose Connections.—See "General Instruction" No. 6.

Loose Connections.—See "General Instruction" No. 6.

Trouble.—All compensarcs are carefully inspected at the factory and tested on a projection arc lamp *under actual operating conditions,* as nearly as they can be secured in a factory, therefore when the machine is received by the operator it is ready to set up and run. If trouble is experienced do not blame the machine until you are certain it does not lie in some part of the equipment or in some local condition.

Ordering Repairs.—If it is at any time necessary to order repair parts, such as new brushes, new bearings, etc., bear carefully in mind the fact that *the serial number and name plate readings of the machine must be placed on the order.*

D. C. Compensarcs.—Machine will not start: If the machine does not start first examine the fuses and make sure that the power is on at the switch terminals. Then trace and inspect the connections from the switch through the starting box, armature, brushes, field and back to the switch, and an opening in the circuit will probably be found.

Fuses Blow: If the fuses blow make sure they are of proper size for the amperage used, and not loose in their contacts. Examine the starting box for grounded or short circuited resistance coils. Look inside the machine and see that the connections are not touching inside where they are

not easily seen. See that the brush yoke and housing marks agree, to insure that the brushes are set in same position as when adjusted at the factory. Look all around the commutator at the connections between the armature windings and the commutator bars. Such minute inspection should locate the trouble.

A. C. to D. C. Compensarcs.—Machine does not start: If the machine does not start when the switch is closed, first examine the fuses and make sure the current is on at the switch terminals. It sometimes happens that a single fuse has blown on a three-phase three-wire outfit, in which case the compensarc will run as a single-phase machine, but if stopped will not start again until the blown fuse has been replaced if a single throw switch be used. However, if a double throw starting switch be used the compensarc will be started up on the unfused side. Therefore, the missing fuse must be detected by the operation of the machine while running. If a fuse is missing it can usually be detected by the unusual noise made by the machine while running, by the motor end heating excessively, and more particularly by change in speed with change in load, and general unsteadiness of the arc. If a fuse be blown it should be replaced immediately, else it may cause the burning out of the motor.

D. C. and A. C. to D. C. Compensarcs.—Sparking at the brushes: When a vicious sparking develops under the brushes of the compensarc it is an indication that something is radically wrong. The most usual causes are dealt with fully under General Instruction No. 8, Page 372. In addition it may be noted, however, that in removing the brushes from the boxes for cleaning, which should be done once a week, *do not take the pig tails loose from the brush holders*, and be sure to place the brushes back in the boxes in their original position, for if they are turned around they will not fit the commutator surface. The brushes should have a smooth, unscratched surface, free from any copper deposit.

Open or Short Circuit in Armature: This trouble will most often occur where the armature winding is connected to the commutator, and results generally from a bruise in handling, from some foreign body getting caught in the armature, or from a chip caught when the commutator is being turned or repaired. If an open circuit the trouble is very apparent, since the long heavy spark accompanying it generally eats away the mica between the segments on each side of the break, thus indicating its location. A short circuit in the

armature will show at once by the excessive heating, and perhaps smoking of the coil or coils short circuited and if the machine is continued in operation it will be burned out. Where trouble of this kind is suspected the necessity of prompt attention by an electrician is obvious.

Overload: If considerably more current is being taken by the lamp than the machine is designed for, sparking may result. See that the machine is not excessively overloaded.

Brushes in wrong position: If the brushes are left in the same position as when the machine is received, trouble will not occur from this cause. If brushes are ever moved or changed, see that they are put back where they belong, and that marks on brush yoke and bearing housing agree.

Machine makes excessive noise: This is most often due to a weak floor, or to the machine not setting firm and level. If the noise seems to be in the machine itself, and nothing can be observed out of place, send for an electrician, as the trouble may be serious.

Bearings run hot: See General Instruction No. 10.

TO SECURE THE BEST RESULTS

(1) Keep the machine clean.

(2) Keep the oil wells full (not overflowing) of good clean lubricating oil.

(3) Keep the commutator and brushes free from gum and grease.

(4) Keep contacts clean and tight.

(5) Keep lamp and wiring free from grounds.

(6) Keep the current at the arc within the rating of the machine.

When repair parts are needed it is poor economy to try to get along without them. Brushes and bearings for these machines can be shipped on short notice and will always be of correct size and quality. In ordering from the manufacturer simply give the nameplate marking, serial number, etc., and no difficulty will be experienced in promptly securing the desired parts.

The Wotton Vertical Rexolux

THE Wotton Rexolux is a new, vertical motor generator set, manufactured by the Electric Products Company, Cleveland, Ohio, designed particularly for motion picture work. The word "Rexolux" is a trade name meaning King of Light.

This machine is a vertical motor generator set, converting alternating current of standard line voltage into direct current at arc voltage. The machine is built vertical with a view of allowing its installation in the operating room, even when space is limited, thus placing the machine directly under the eye of the operator; also, the vertical design permits of a rugged form of construction which tends to reduce vibration and noise to a minimum; also it makes the machine very accessible and easy to assemble and disassemble.

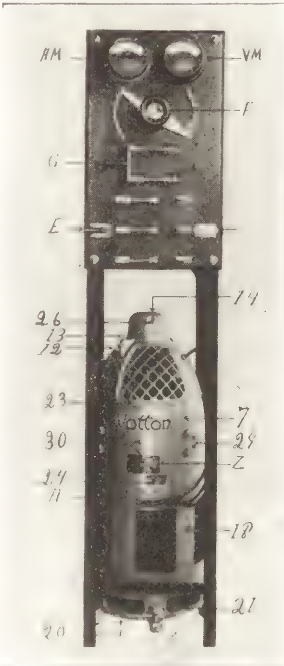


Plate 1, Figure 189.

The Rexolux 's built in three sizes, viz: a machine designed to operate a single projection-arc lamp; a machine to operate two lamps alternately, and one to operate two lamps continuously. Where two lamps are operated continuously only the 70 ampere machine is available.

The 50 ampere machine, of either the M, MA, or MMA type (the meaning of these different types will be explained later on), occupies a floor space 17 by 20 inches, and has a vertical height of 34 inches to the top of cap 14, P. 1. The switchboard, supported by angle irons, is immediately over the machine, so that the entire space required for the 50 ampere equipment is 17 by 20 inches on the floor, by 5 feet in vertical height. The 35 ampere machine is 3 inches less and the 70

ampere is 3 inches greater in height, but the floor space required is practically the same for all the types.

In referring to the ampere capacity of the above machines, the ratings are based on continuous operation. The 35 ampere machine will carry 50 amperes, the 50 ampere machine 80 amperes and the 70 ampere 140 amperes for short periods of time, meaning by this that these machines will carry full load continuously, and stand the overload named for short periods, say not exceeding two or three minutes.

These machines are built for all standard voltages and frequencies, viz: 110, 220, 440 and 550 volts; 25, 30, 40, 50 and 60 cycles, single, two and three phase.

Construction.—Referring to Plate 2, Fig. 190, it will be seen that the machine consists of four main castings, viz: base casting 20, which rests directly on the floor, and con-

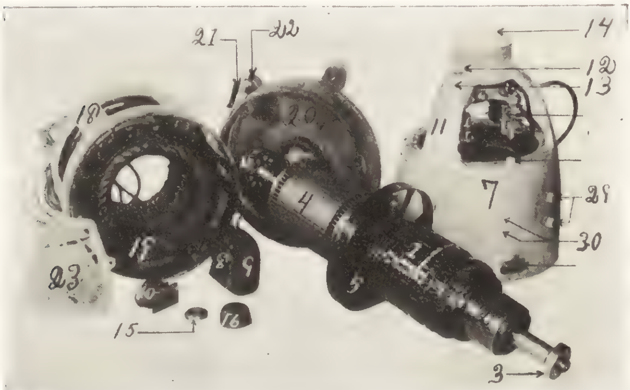


Plate 2, Figure 190.

tains in its center the cup or depression carrying ball race 6, which supports the entire armature; casting 18, which rests on base 20 and forms a housing for the alternating current driving motor, the detailed construction of the windings of which are plainly seen at 19, Plate 2; main upper casting 7, which supports the pole pieces of the D. C. generator, and upper yoke casting 11, carrying grating 23, the upper armature bearing, and cap 14, Plate 1; main upper casting 7, Plate 2, and yoke castings 11, Plate 2, are held together by bolt 27, Plate 2, dividing at the dotted line.

The armature stands vertical (on end), with the rotor of

the alternating motor, 4, Plate 2, below, fan 5 above rotor 4, and armature 1 with commutator 2, above the fan, the upper end being supported laterally by a ball bearing, construction of which is shown in detail in Plate 3, Brush holders and brushes 17 are shown in Plate 2.

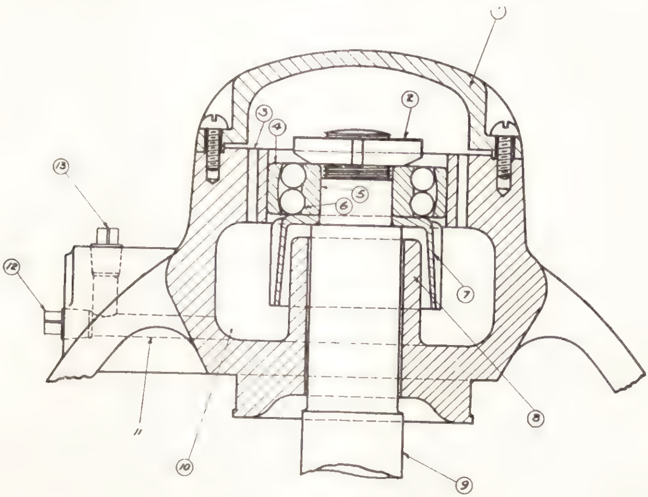


Plate 3, Figure 191.

The details of upper bearing 3, Plate 2, are shown in Plate 3, in which 4 and 5 are, respectively, an exterior and interior ball race, separated by steel balls 6, part 5, the interior race being clamped rigidly to shaft 9, by means of nut 2. Part 4 is stationary and sets in a recess in the main frame casting, the whole being covered by cap 1. Part 7 consists of a casting which is clamped between interior ball race 5, and the shoulder of shaft 9, so that it must revolve with the shaft at armature speed. This part (7) extends down into oil well 10. The oiling action is as follows: Oil well 10 is filled with oil up to approximately one-quarter inch of the top of the passage containing plug 13. Part 7 revolves at high speed, and, by the centrifugal action thus created the oil is forced up through passage 3-3, whence by gravity it returns again to the well through the bearing, thus flooding balls 6 with a continuous stream of oil.

Thirteen, Plates 1, 2 and 3, is a plug closing the passage

through which oil well 10 is filled. *It is essential that this plug be in place and screwed tightly home, else the centrifugal action before named will force the oil out and empty the well.* Plug 12, Plates 1, 2 and 3, is for the purpose of draining oil well 10, and *this should be done at regular intervals every thirty days.* After draining the oil well, insert plug 12 and fill the well with kerosense, start the machine and let it run for say two minutes, after which drain all the kerosense out, replace plug 12 and fill the well up to within one-quarter inch of the top of the passage stopped by plug 13.

As the quality of oil to be used, see General Instruction No. 3, but:

Caution.—*Never, under any circumstances, use the much advertised patent oils, as they almost without exception are worthless for the lubrication of heavy or high speed machinery.* The use of such oils will invalidate the manufacturer's guarantee.

On the other, or lower end of the armature shaft, is ball bearing 6, Plate 2, lubrication for which is furnished by grease cup 21, Plates 1 and 2. This grease cup should be kept filled with Alco Grease.

Caution.—*It is important that either Alco Grease or a high grade vaseline be used, because of the fact that if a grease containing any acid is used in cup 21, the acid will attack the steel balls, and in course of time destroy their accuracy, thus compelling an unnecessary and somewhat expensive renewal of the bearing.*

Armature.—The armature or revolving member of the machine is completely assembled into one solid part, 1 to 6, Plate 2, in which 3 is the upper and 6 the lower bearing. The alternating current rotor, or revolving member, 4, is built up of reannealed electrical sheet steel, properly punched and assembled on armature shaft 9. The rotor bars are driven through the slots a tight fit, the ends electrically welded together into a solid mass of pure copper, which insures perfect contact, low resistance and a uniform torque, or pulling force. Directly above the rotor is fan 5, Plate 2, made of sheet steel blades and a solid ring, the blades riveted and welded together, and finally attached to shaft 9 by means of two heavy set screws. This fan produces a suction through the ventilating openings in castings 18 and 20, drawing cold air over the windings of the A. C. motor. This air is then forced up over this D. C. armature, and out through openings 23, Plate 1.

Part 1, Plate 2, is the D. C. armature, which is mounted directly above fan 5. Armature coils are fixed in place with

retaining band wires where the connections are made to commutator 2, Plate 2. The commutator is made up of hard drawn copper segments, insulated with mica, and held in place with steel rings clamped with four bolts. The D. C. generator is of the four-pole type, and is provided with commutating or inner poles.

Brushes.—The setting of the brushes is shown in Plate 4. There are four brush studs, 17, Plate 1, and two brushes to a stud. These brushes are attached to the holders by copper "pigtails." Particular care should be exercised to see that the screw holding the pigtail to the brush holder is kept set up tight, because unless the pigtail makes good contact with the holder, the tension spring will be compelled to carry current, which would probably heat the brush spring and destroy its temper.

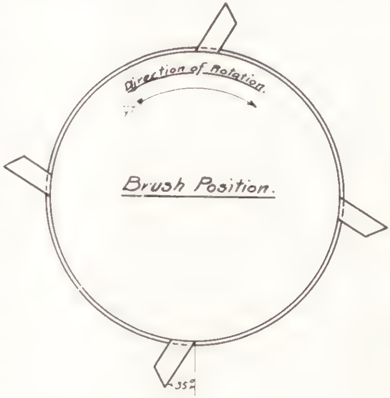


Plate 4, Figure 192.

With regard to the amount of tension the brushes should have see General Instruction No. 8.

The brushes are held in place by a curved arm passing around the holder, ending in a tension finger fitting on the top of the brush. The brushes are held to the commutator *against* the direction of rotation. The amount of tension can be adjusted by the spring and ratchet on the side of the brush holder.

Care of Commutator.—With regard to the care of the commutator, see General Instruction No. 8.

The A. C. driving motor is the induction type, and is built either for single, two or three phase current, but the same machine will not operate on different phases. All standard machines are built to operate on both 110 and 220 volts.

Installation.—See General Instruction Nos. 1 and 2.

The Rexolux is so built that it may be readily disassembled, since owing to its weight it would in many cases be difficult to hoist it in place in an operating room as a unit. In order to disassemble the machine, proceed as follows:

First, open gratings 23, Plate 1, and remove the commutator brushes from their holders, allowing them to hang by their pig-tails so that you can make no mistake in getting them back into their proper holder. Remove screws 26, holding cap 14, Plate 1. Remove nut 2, Plate 3. Remove nuts 24, Plate 1 (four of them). holding main upper casting 7, and main lower casting 18 together. Screw the eye-bolts provided into holes in main upper casting 7. (These holes were not in the first machines put out). Thrust pieces of gas pipe or steel bars through the eye-bolts and lift main casting 7 straight up and off, laying it to one side, but right side up so that oil will not run out of oil well 10, Plate 3. Next carefully lift out the armature, first, however, having provided two blocks or chairs, and *lay the same down flatways on these blocks or chairs, so that the weight is entirely supported by the shaft.*

It is very important that you do *not* lay the armature down so that it rests on the side of the alternating current rotor 4, fan 5, or direct current armature 1, or commutator 2, since any injury to these would be a very serious matter indeed. Handle the armature carefully and use a little horse sense, if you wish to avoid trouble. The machine may now be hoisted or carried into the operating room, where its reassembling will merely be a reversal of the process of disassembling. First carefully lower the armature into place, being careful that alternating current rotor 4, Plate 2, be on the lower end. Next replace casting 7, and tighten up nuts 24, Plate 1, tight. Replace top ball races and nut 2, Plate 3, *tightening nut 2 down as tight as you can get it.* Replace cap 14 and screws 26. Rotate the armature by hand to see that it turns freely, after which replace the brushes in their holders, put gratings 25, Plate 1, back into place, and the job is done.

Be sure and wipe the inside of the top casting clean, since if any oil should get on it, it would collect the copper dust from the commutator and might cause a ground on the brush yoke. See that the casting and brush yoke are thoroughly cleaned of all oil and dust before it is put back in place. It would be preferable to wash them with a cloth dipped in gasoline, wiping with a clean, dry cloth afterward.

Bolts 29, Plate 1, hold pole piece 8, Plate 2, which carries coil 9, Plate 2, in place, and should not be removed under any circumstances, unless the coil be damaged and require rewinding. There are four of these pole pieces and eight bolts, two bolts per pole piece. Bolts 30, Plate 1, hold

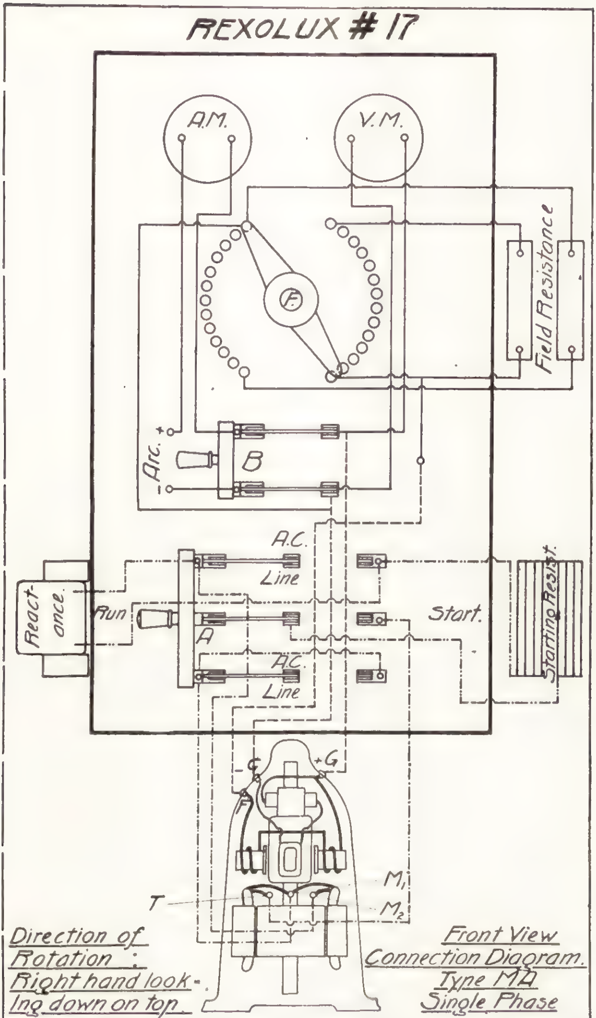


Plate 5, Figure 193.

inner poles 10, Plate 2, in place, and should not be removed under any circumstances unless the coil is burned out and requires rewinding.

Remember the switchboard sets directly over the machine, as shown in Plate 1. With each machine there is furnished four cork pads, 2 inches square by 1 inch thick, which are to be placed under the feet of the machine, where they act as a cushion, absorbing noise and vibration. It is not necessary nor do we recommend screwing the machine to the floor with lag bolts. Its weight is sufficient to hold it in place.

ELECTRICAL CONNECTIONS—TYPE MA SINGLE ARC REXOLUX

In Plate 5, lines G-G show the direct current circuits. The current from the positive generator brush passes out at + G, thence over the evenly dotted line to switch B (G, Plate 1), which when closed, connects, after passing through the ammeter, with the positive carbons of the arc lamp. From the negative brush of the generator the current passes through the various interpole coils in series, then out at — G, thence similarly up to the negative side of switch B, and thence to the arc. In order to obtain the necessary field regulation, the extra lead from the shunt field is brought through the frame at F, Plate 5, and thence up to the field regulating resistance. The voltmeter is connected across the terminals of the arc at the right hand side of switch B. This completes the direct current connection for the type MA single arc Rexolux.

Were it not necessary to obtain a self-starting motor, in single phase machines, it would then require but one set of windings. In order, however, to obtain the necessary starting torque, a second set of wire coils is superimposed upon the main power coils. This set of starting coils is thrown out of phase with the power coils by inserting in series therewith a starting resistance and reactance, shown opposite starting switch A, Plate 5. The main power coils terminate in the frame at "M1" and "M2," Plate 5, and the terminals of the extra starting coil at T, the other end of which is connected inside of the machine to the main power coils. The lines designated by a dash and a dot constitute the alternating current wiring of the system.

Where two or three phase current is supplied it is not necessary to use the extra starting coils, or the starting

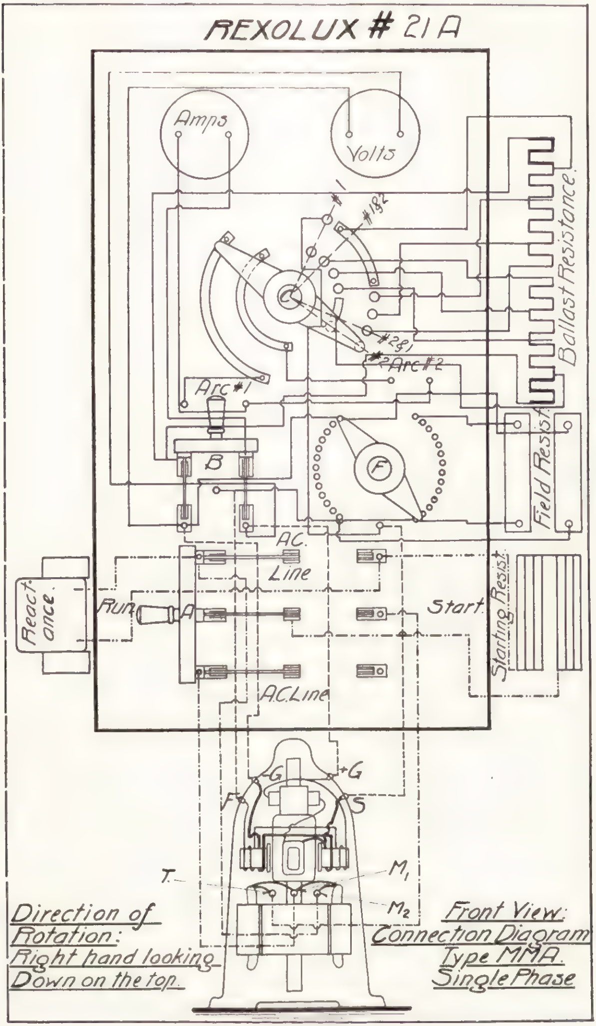


Plate 6, Figure 194.

resistance or the reactance. In this case the wiring incident to the starting features of the single phase motor is omitted.

ELECTRICAL CONNECTIONS—TYPE MMA—TWO ARC REXOLUX

An examination of Plate 6 will show that the motor starting and control is identical with that shown in Plate 5, therefore what has already been said of Plate 5 applies. By reason of the fact that a shunt wound generator drops its voltage when overloaded, thus automatically protecting itself when the carbons are brought together for the purpose of striking the arc, the shunt wound generator is ideal. Since, however, upon short circuiting the carbons the field of the machine is entirely destroyed, it is impossible to run a shunt wound machine and keep one arc burning while the other is struck. During the period of changing from one projector to another to dissolve one picture into the next, it is necessary to operate the generator temporarily during the changeover interval, as a compound wound machine. The regulator shown above the center of the board accomplishes the changeover from shunt to compound wound during the time both arcs are burning, and then back to the shunt again when ready to extinguish one of the arcs. Regulator C accomplishes the whole changeover process without touching anything else.

As in the previous description "+ G" and "— G" are the main generator leads as they pass from positive and negative brushes respectively to the generator frame. In the two-arc machine, however, the current passing from the negative brush first passes through the system of interpoles, thence through a separate series winding, wound on the main generator field poles. A tap is taken between the end of the interpole system and the beginning of the series winding and carried out through the frame at "S." The shunt field wire passes through the frame at "F" as heretofore. When, therefore, "+ G" and "S" are used as the main generator terminals, the machine is running as a shunt wound generator, similarly when "+ G" and "— G," it is running as a compound wound generator.

In the special regulator "C" the inner set of buttons and segmental contacts control one arc, similarly the outer set the other. There are two similar regulator blades insulated from each other and moving together, one being elevated above the other. With the regulator blade in position No. 1,

the generator is operating as a shunt wound machine with arc No. 2 shown open circuited. With the regulator in position No. 1 and 2, circuit "S" for the generator is opened and connection "— G" is used. The machine is therefore running as a compound wound machine. In passing over to position 1 and 2 from arc 1 the arc No. 1 (controlled by the outer set of contacts) has also inserted with series therewith just enough ballast resistance to counteract the increased field strength due to cutting in the compound winding.

This prevents a flicker on the screen which would otherwise ensue. Arc No. 2 (controlled by the inner set of contacts) has connected in series therewith its maximum resistance. This is sufficient to limit the short circuit current when the carbons of arc No. 2 are brought together to 15 amperes. By moving over to the two following buttons arc No. 1 remains as it was at Nos. 1 and 2 and steps of resistance are cut on arc No. 2, thereby increasing the amperage to about 35. The regulator is allowed to remain in this position until the carbons of arc No. 2 are well burned in, after which the regulator is quickly thrown to its final position No. 2. This extinguishes arc No. 1 and leaves arc No. 2 burning from a straight shunt wound generator.

To pass back to arc No. 1 when the reel is completed on arc No. 2 the inverse order is followed, the explanation being identical. In this type of machine the connections from the switchboard to arcs Nos. 1 and 2 are made from the studs shown and marked accordingly. The entire function of the regulator "C" in the two arc machine is to take advantage of the perfection of both types of machine, shunt and compound, during the points in the transition at which they are of greater value.

MARTIN ROTARY CONVERTER

Figure 195 shows a general view of the Martin Rotary Converter, manufactured by the Northwestern Electric Company.

According to literature which I have seen this device is made for 25, 30 and 60 cycle, 110, 220 or 240 volt supplies, delivering 60 to 80 amperes D. C. at the arc. Fig. 196 shows the general construction of the machine.

The manufacturers of this device were invited to supply proof of its electrical efficiency and cuts for its description in the Handbook, on the same terms accepted by other manufac-

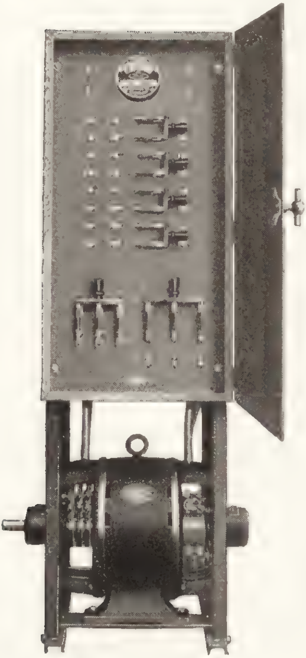


Figure 195.

turers, viz: supply the cuts and assist in the preparation of the matter. They were invited to do this not once, but several times, and refused. Therefore beyond showing what it looks like, and how it is constructed, I can only say that I have had both favorable and unfavorable reports as to this particular apparatus. From such information as I have had I believe the machine is well made mechanically, but that its electrical efficiency is rather low, due to the fact that it generates D. C. at 70 volts and brakes down the surplus pressure with resistance. On the other hand its manufacturers claim, and I think their claim is well founded, that when their machine is used one reel can be dissolved into the other without in any way effecting the picture on the screen; also the resistance used to break down the surplus voltage makes the arc comparatively steady and easy to handle.

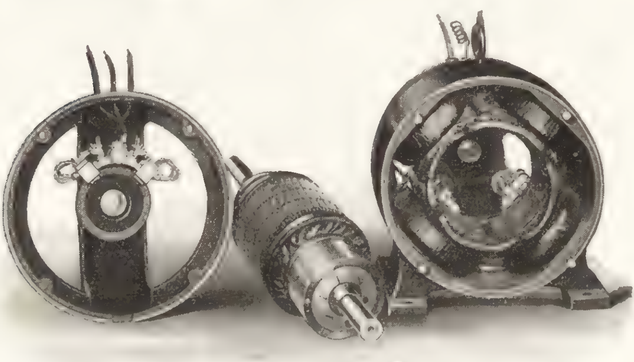


Figure 196

The Rotary Converter

THE "Wagner White Light Converter" combines a motor and generator in one machine, having but one field and one armature winding. The motor action is that of a synchronous motor, which makes it necessary that the armature be brought up nearly to full speed before it can be run as a synchronous motor. The machine is built for single, two or three phase circuits, and for 25, 50 and 60 cycle current, of any voltage from 110 to 550. The direct current voltage is 65 to 75, and the amperage capacity of the various sizes 35, 50, 70, 90 and 100 amperes. The 35 ampere converter is intended for use in theatres where but one projection machine (one arc) is used. The 50 ampere size may be used in theaters having two projectors, provided the two arcs be not burned simultaneously for a period of more than two minutes.

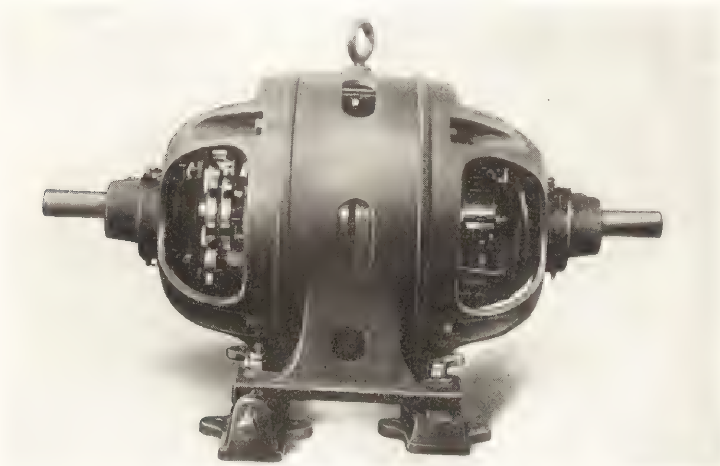


Plate 1, Figure 197.

Plate 1 is a view of the Wagner single phase converter. Plate 2 is a view of the same machine disassembled to show the construction and parts. The mechanical construction of the single, two and three phase converters is practically identical, except as to the number of slip rings and brushes.

By reference to Plate 2, the following parts are designated by number: 2, A. C. or slip ring brushes; 3-3, end plates; 4, slip ring brush leads; 5, frame; 6 stator or field

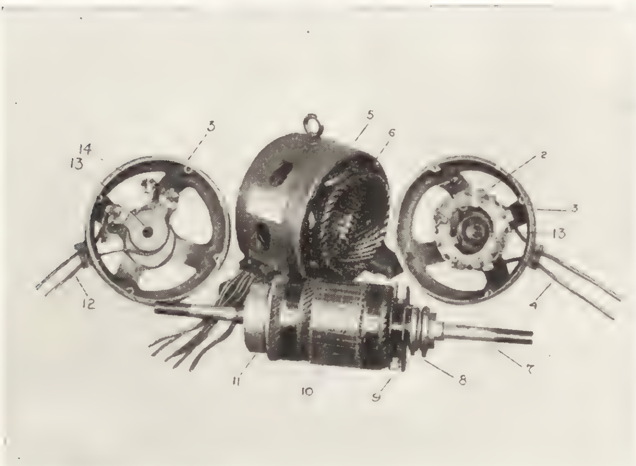


Plate 2, Figure 198.

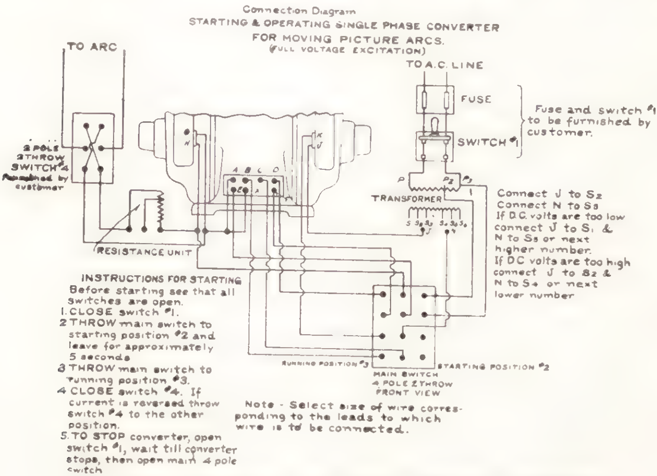
windings; 7, armature shaft; 8, slip rings; 9, ventilating fans; 10, armature; 11, D. C. commutator; 12, D. C. leads; 13-13, main bearings; 14, D. C. brushes and brush holders.

The armature shaft, 7, P. 2, runs in bronze bearings 13-13, P. 2, and underneath these bearings are oil chambers from whence a constant supply of oil is fed to the bearings by rings. See Fig. 179. These bearings are mounted in end plates, 3-3, P. 2, which are single-piece castings, bolted solidly to main frame 5, P. 2, thus insuring rigidity and freedom from vibration. The shaft projects from the bearings at either end a sufficient distance to accommodate a pulley, so that when not generating direct current the converter may be used as a motor for driving light machinery, such as ventilating fans. *It is not intended, however, that the converter be used to drive machinery and generate direct current at the same time.* To attempt this might cause overload which would probably do serious injury to the armature windings.

Once the converter has been started it requires no further

attention, unless the power should for any reason be cut off for an appreciable period, in which case it will be necessary to restart the motor.

Plates 3 and 4 are wiring diagrams of single phase converters, the only difference being in the starting switch. Single phase converters may be furnished with either three



Connection Diagram for Single Phase Converter.

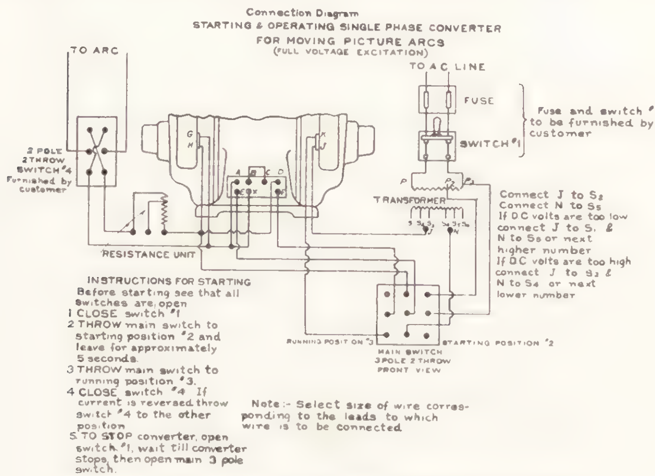
Plate 3, Figure 199.

and four pole starting switches, and both diagrams are, therefore, given here. Plate 5 shows the wiring of a two phase converter and Plate 6 of a three phase converter.

Single phase converters are furnished with a single transformer, while two and three phase converters are furnished with two transformers each. Wagner converters must take their A. C. supply through transformers, as they are wound to operate at a certain definite ratio between the A. C. supply and the D. C. delivery voltage, hence the voltage of the supply must be "stepped down" to that pressure which will cause the converter to deliver D. C. at the required voltage. This plan has one big advantage in that, should the voltage of the A. C. supply be altered at any time, as for instance from 110 to 220, the only part of the equipment it would be necessary to change would be the transformer or transformers.

By examining the wiring diagrams and Plate 7 it will be

noted that a number of connections may be made at the transformer by means of which one may raise or lower the A. C. supply voltage of the converter. These connections are marked S1, S2, S3, S4, S5, and S6 in the diagrams and on Plate 7. This arrangement gives an available range of voltage from 65 to 75 on the D. C. side of the converter, or allows one to maintain the voltage at any required point in case the alternating current supply voltage is variable. The wiring diagrams explain the method of using these taps.



Connection Diagram for Single Phase Converter.

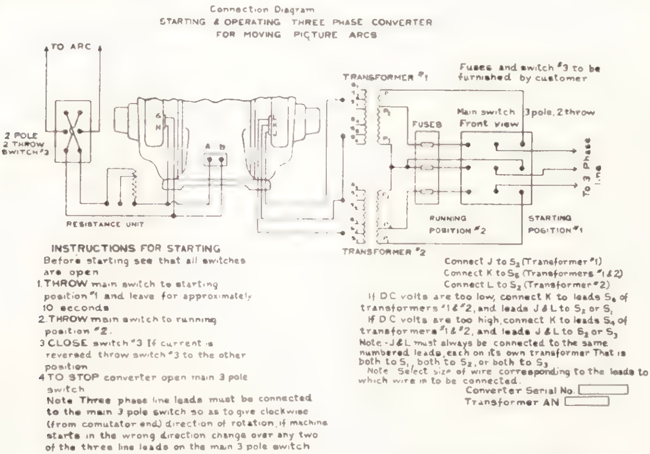
Plate 4, Figure 200.

The Wagner converter may be used with any one of five different styles of resistance (rheostat) especially designed for this equipment, the same being designated as follows: Non-adjustable for single arc, Non-adjustable for multiple arc, Adjustable for single arc, Adjustable for multiple arc, and Duplex arc regulator.

It is hardly necessary, I think, to enter into explanation of these resistances, with the exception of the "Duplex Regulator." This resistance is so connected that the moving of a single handle introduces by gradual steps the full value of the resistance into the circuit of one arc, at the same time reducing the resistance in the circuit of the other arc to a

minimum, thus maintaining a uniform load on the converter during the process of fading one picture into another; *i.e.*, changing from one projection machine to the other.

The Wagner converter generates D. C. at from 65 to 75 volts, hence it is necessary to use sufficient resistance to break down this voltage to that of the projection arc, which varies from 45 to 55. This resistance serves the purpose of a steadying ballast, making the arc steady and easy to handle.



Connection Diagram for Two Phase Converter.

Plate 5, Figure 201.

Installation.—Place the machine on a firm, level foundation, in a clean, light place, high enough from the floor so that it may readily be kept clean, and so that dust and litter cannot accumulate under it. Install the machine far enough from the wall so that it will be accessible from either end. See General Instruction Nos. 1 and 2.

Wiring.—The wiring from the converter to the control board (on starting switch) must be done according to local and underwriters' rules. A diagram of connections is sent with each converter, and is printed herewith, which diagram *must be strictly followed. The connecting cables for an ordinary length of run should be at least as large as the corresponding converter leads. If the run is a long one the cables should be larger.*

Oiling.—A moderately heavy mineral bearing oil should be used, and the oil should be changed after each 200 hours of run. The oil level in the oil box should be kept about one-quarter inch below the lower part of the shaft. See General Instruction No. 3.

Brushes and Care of Commutator.—Before starting a new machine, examine end plate on commutator side and see that the small pointer fixed on the end plate is opposite the chisel mark on the rocker arm carrying the brushes. If it is not then move rocker arm until it is.

Should the brushes begin to spark under normal load it will probably be found that the commutator has worn unevenly and needs smoothening. Procure a sheet each of coarse and fine sandpaper, preferably garnet sandpaper. *Do not under any circumstances use emery paper or emery cloth.* (This stunt is recommended by the manufacturer, not me.—Author.) Obtain a flat piece of wood about the same width as the commutator; place the coarse sandpaper around it and hold against the commutator when machine is running. Give the sandpaper just enough lateral (side) movement so that all parts of the commutator may be smoothed down evenly. When the rough places are all out, complete the smoothing process with fine sandpaper, using lighter pressure. See General Instruction No. 8.

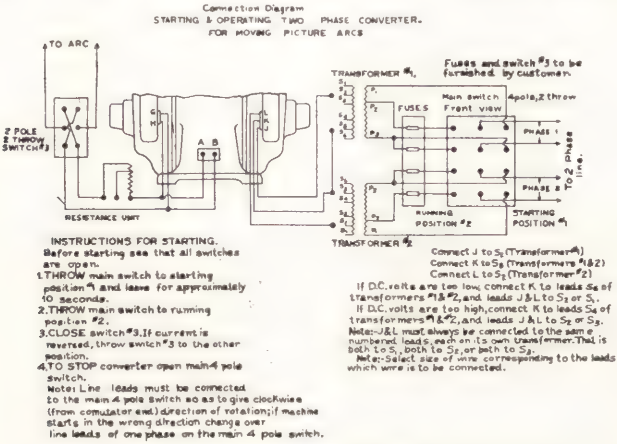
Fitting Brushes.—When it is necessary to fit new brushes, proceed as follows: With the machine stationary, and the brushes fitted into the brush holders, a piece of coarse sandpaper is placed on the commutator, rough side toward the brushes, and grasping the sandpaper with one hand each side of the commutator, pull the sandpaper rapidly back and forth and the brush will be ground down and take the same curve of the commutator. See General Instruction No. 8.

The brushes used on this machine are made especially for it, and are a mechanical mixture of metallic copper and carbon. *When new brushes are required they should be purchased from the Wagner Electric Manufacturing Company.*

Starting a New Machine.—After the installation and wiring has been completed, look well to the follwing points: (1) See that the A. C. line fuses are in place. (2) See that the converter oil boxes are filled with oil. (3) See that the pointer on the end plate coincides with the chisel mark on the rocker arm carrying the brushes. Everything is now ready for starting up and the instructions which are sent out with each converter (and printed here) should be carefully studied. *See that all switches are in the open position,*

then: (1) Close A. C. line switch. (2) Throw main four-pole switch (or three-pole as is the case) to *starting* position, and *leave for approximately five seconds.* (3) At end of five seconds throw main switch to *running* position. (4) Close polarity changing switch either way. (5) Bring the arc lamp carbons together, and quickly draw them apart to start the arc.

On account of the peculiar characteristics of the converter the polarity of the arc lamp may at times be reversed in starting, and it is therefore necessary that a polarity reversing switch be



Connection Diagram for Three Phase Converter.

Plate 6, Figure 202.

included between the D. C. resistance and the arc. This switch is shown in Plate 4. After starting the converter and arc, if it is found that the polarity is reversed and the crater is forming on the negative carbon, the polarity switch should be thrown over. (6) To stop converter open switch 1, wait until the converter stops, and then open main four-pole switch.

It sometimes happens that trouble is experienced in starting the converter for the first time. The most common sources of trouble are: Converter will not start after closing A. C. line and throwing three or four pole switch to starting position. This may be caused by any one or more of the following things: (a) A. C. line fuses either not in place or faulty. (b) Switch contacts not making good con-

tact with the switch jaws. (c) Brushes lifted off commutator. (d) Mistakes in connecting up.

If no trouble is experienced in getting the converter started it sometimes happens that the fuses blow upon throwing the four-pole switch over into starting position. This may be caused by switching over before the motor has attained its full speed. Until the operator gets experience in estimating the correct motor speed it is advisable for him to time himself. On the other hand, too long an interval must not be allowed or the converter will pass the synchronous speed. It is expected that five seconds will bring the armature up to proper synchronous speed.

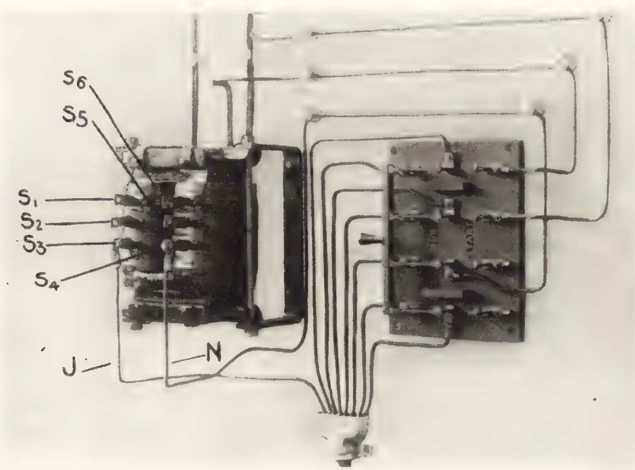


Plate 7, Figure 203.

If the converter stops after switching into running position 3, examine the slip ring brushes, also the transformer connections, and see that the switch blade and jaws are making good contact. If a vicious sparking is seen on the commutator it indicates a break in some of the connections running to leads A, B, C, D, Plates 3, 4, 5 and 6. This trouble can be readily recognized if a polarized D. C. voltmeter is connected across leads G and H. It is evidenced by a periodic swing, forward and back, of the voltmeter needle. If there is continuous sparking, the switch contacts

and blades connecting to converter leads E and F should be examined and any faulty contact made good. If this does not remedy matters the trouble may be due to commutator being rough, though this is not a trouble to look for in a new machine. It has been assumed that the operator has made sure that the pointer on the end plate is opposite the chisel mark on the rocker arm, as sometimes the rocker arm gets displaced during shipment, and such displacement will cause sparking.

Hallberg's D. C. to D. C. Economizer

THE Hallberg D. C. to D. C. Economizer consists essentially of a D. C. motor which pulls a specially wound generator delivering current to the arc at arc voltage, without any resistance in series. The only waste is, therefore, that consumed in the machine itself. In other words it costs more than the rheostat, but saves the difference between its efficiency and the efficiency of the rheostat. This is very great on voltage of 220 or more, and is considerable on 110. The manufacturer claims the following:

HALLBERG DIRECT CURRENT ECONOMIZER DATA

Line Input				Output at Arc				
Line Fuses Required.	Line Volts.	Line Amperes.	Line Watts.	Arc Voltage.	Arc Amperes.	Arc Watts.	Watts Loss.	Efficiency.
20A	110	17	1,870	50-55	30	1,650	220	88%
10A	220	10	2,200	50-55	30-35	1,650	550	75%
5A	550	4	2,200	50-55	30-35	1,650	550	75%

The table or data is explicit, and if the manufacturer will base the payment of his bill upon the accuracy of the figures given the machine ought to prove a good investment even for 110 volt current, since the control of D. C. through a rheostat is, as we all know, enormously wasteful. A rheostat has considerably less than 50 per cent. efficiency.

Fig. 204 illustrates the general make-up of the 110 volt type of economizer, which, while being constructed along the lines of a motor generator, is in the strict sense of the word only in part a motor generator. The principle involved is original with Mr. Hallberg and permits the use of a smaller and more efficient motor and generator than would be possible were the apparatus a straight motor generator set. The 110 volt outfit is provided with an automatic starting box and light controller by means of which the operator can vary the amperes at the arc anywhere

from 20 to 30, on the 25 ampere size; from 30 to 40 amperes on the 35 ampere size, and from 40 to 60 on the 50 ampere size. It is, of course, possible to secure lower ampere output than specified as a minimum with any of the above machines by the use of special controllers, which can be furnished upon request.

Fig. 205 illustrates the Hallberg D. C. economizer as made for voltages ranging from 200 to 750. This outfit is a straight motor

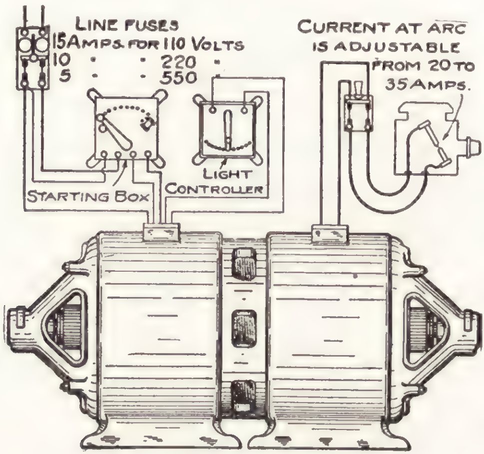


Figure 204.

generator set, in which, however, the generator is of special construction delivering a steady ampere flow to the arc without the use of a rheostat. The 200 to 750 volt outfit is also furnished complete with automatic starter and light controller, and besides this outfit has a pully coupling between the motor and generator on which, in special cases, a belt may be placed for driving the economizer by means of an engine, which would make the economizer operate a motion picture arc just as it does when driven from an electric circuit, and at the same time from the high voltage side current can be taken for driving fan motors, or a limited number of lamps. This is an important feature and might, under some circumstances, be of considerable value to an exhibitor.

Another feature of construction is that the low voltage side of the economizer is a separate unit which can be run as an ordinary dynamo by an engine ranging from 3 to 6 horsepower in capacity

for the operation of a motion picture arc. The other half of the machine, representing the high voltage side, is an ordinary electric motor which can be taken off its base in a few minutes' time and used as a regular electric motor, together with its automatic starter. These are points of economy which represent certain advantages to the purchaser of this class of apparatus. It is not practical to give wiring diagrams, showing the connections for these machines, because they vary for different voltages and cur-

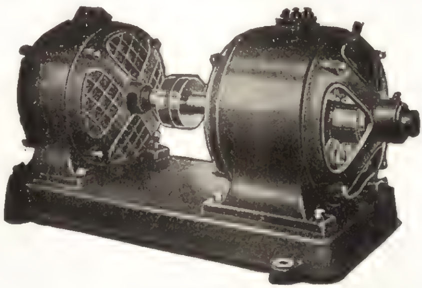


Figure 205.

rents, and as these machines are generally built to specifications to suit the individual operator or manager, it is best to depend upon the blue print and diagram of connections which accompany the shipment, and if the instructions should be lost, another set can be readily obtained at the office of the manufacturer.

INSTRUCTION FOR SETTING AND OPERATING

1. **Installation.** (See General Instruction Nos. 1 and 2.)

2. **Connections.**—All connection should be made as shown in the wiring diagram sent with each machine. They must be clean and tight. Fuses should not have a higher capacity than that indicated by the diagram.

3. **Brush Tension.**—After the machine has been properly set and connected, rotate the armature by hand and examine each and every carbon brush to make sure that it moves freely, without the slightest friction in the brushholder which guides it. Make sure that the flexible copper cable, or pigtail, as it is called, is properly clamped by the screw in the brushholder casting provided for that purpose. When the brush is in proper condition and moves freely in the holder, the next point to be looked after is the spring tension which pushes the brush against the commutator. See General Instruction No. 8. The

brush tension spring is adjustable by putting the end of it in the different notches provided for it in the brushholder casting, and any degree of tension can be had by using the different notches.

4. **Oiling.**—The oil chambers should contain enough oil to give the rings a good dip. The oil level will be seen in the gauge on the sides of the bearings and should be merely at the top of the gauge. When starting the machine, lift oil chamber covers and see that the oil rings are turning freely and carrying oil to the shaft. The old oil should be drawn off by unscrewing the drainage plug at bottom of the bearing every month or two, and replaced with new oil. See General Instruction No. 3.

5. **Setting of Brushes.**—Machines are shipped from the factory with the brushholders and brushes properly set. The position of the brushes is approximately half way between the poles. In the motor, they are placed one or two segments back (that is, against the direction of rotation) of the exact middle or neutral point, while in the generator they are set one or two segments forward. The brushholders should be placed on the studs, so that the brushes will not run in the same line on the commutator. This will help to avoid grooving.

6. **Starting Set.**—First see that the starting box lever has moved back to the off position. If there is a regulating rheostat on the motor end, its handle should be moved as far as possible in a contra clockwise direction. If there is one on the generator end, its handle should be moved as far as possible in a contra clockwise direction. Close the main switch and move the lever of the starting box over the contacts, taking about one second for each, until it is against the magnet which will hold it. If the set has not started when the fourth contact point is reached, open the main switch and ascertain the trouble. When the set is running, the current may be adjusted by means of the regulating rheostats.

7. **Stopping Set.**—Open the main switch and let the starting box operate itself. The lever will be released when the motor has slowed down, when it will fly back to the "off" position. If the contacts become rough and prevent the lever from moving fully back, they should be cleaned with very fine sandpaper. The lever should never be fastened or allowed to stick at an intermediate point.

8. **Care of Brushes and Commutator.** (See General Instruction No. 8.)

Hallberg's Twentieth Century Motor-Generator Set

J. H. HALLBERG, New York, has put out a motor generator set, the general design of which is shown in Plate 1, Fig. 206. The machine occupies a floor space 15 by 31 inches, and is 15 inches in height. Its weight is a little less than 500 pounds in the 70 ampere size, the 40 and 130 ampere machines being respectively less and greater in weight. The machine is compact, rigid in construction, and its parts are easily accessible for adjustment or repair, as is made evident through an examination of the various plates.

The machine is made in capacities of 20-40 amperes, 30-70 amperes, and 60-130 amperes. The 30-70 ampere size is the capacity more largely in demand for moving picture

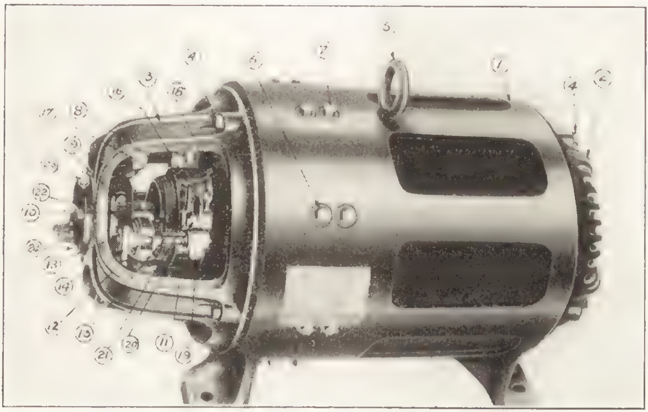


Plate 1, Figure 206.

work, in that it will operate with a fair degree of efficiency on a 30 ampere load, and will carry two 50 ampere arcs for the short period of time necessary to make a change from one machine to the other. It must not be understood from this that the generator will stand up under a 100-ampere load for more than one to one and a half minutes.

The machine delivers direct current to the arc, at arc voltage, without any resistance interposed in the circuit, which means, of course, that it is a specially compounded generator, and, to go a little further, a specially compound-

ed generator pulled by an A. C. motor, the two armatures being mounted on one shaft, and contained in one housing, with a ball bearing at either end of the shaft, both being "ball bearings."

Plate 1 supplies a view of the whole machine, with the various parts numbered.

No. 1.—Lubrication. The lubrication of this machine differs from that of most other motor-generator sets used for moving picture work, in that grease is used instead of oil.

The grease chambers may be filled in two ways: first, if you have purchased your grease in a "gun," or if you have a "gun" which can be filled with grease, having removed screw, 23, Plate 1, and a similar one on the opposite diameter of the grease chamber cover, you can place the spout of the gun in the upper hole and force grease in. This will force the old grease out at the lower hole, and the job w ll be a fairly complete one. This operation must be performed for the grease chamber at each end of the armature shaft. When through you will, of course, replace the screws.

Another way is, if you have no grease gun, to remove screws 24 (four of them), on the end of the cast iron cap which covers the grease chamber. You can then pull the cap off, clean out the old grease, and pack the chamber with fresh lubricant. Where this is done it would be well to wash out the grease chamber thoroughly with kerosene or gasoline.

Still a third way is to remove screw, No. 23, Plate 1, and insert in lieu thereof a compression grease cup having a stem of the same diameter and thread as a one-eighth inch gas pipe. Where the compression grease cup is used when it is desired to force grease in it will be necessary first to remove the screw in the opposite diameter to screw 23, Plate 1, same being immediately below the grease cup, in order to allow an equal amount of old grease to flow out. Where the compression grease cup is used it is merely designed that the cup take the place of a grease gun—therefore it should be a large one and only used to force a large quantity of grease in about once every 60 to 90 days, it being expected that when the run is, say, twelve to fourteen hours per day one greasing will last for that length of time.

Caution: *Don't use any and every kind of grease.* The grease serves ball bearings, and if it contain alkalis or acids you may expect trouble and plenty of it. For this reason my advice is: *Use only grease procured from the manufacturer of the machine.* You may regret it if you do otherwise.

No. 2.—Locating the Motor Generator. (See General Instruction No. 1.)

No. 3.—Installation. (See General Instruction No. 2.)

No 4.—Cleanliness. (See General Instruction No. 4.)

No. 5.—Loose Connections. (See General Instruction No. 6.)

No. 6.—Ammeter and Voltmeter. (See General Instruction No. 7.)

No. 7.—Removing End Bearing Bracket 2, P. 1. It will never be necessary to remove this bracket unless some fault should develop through the use of improper grease, or a very improbable inherent imperfection in the ball bearings, but should such a thing occur you may remove end bearing bracket 2, P. 1, by first removing four hexagon shaped nuts, holding the cast iron cover of the grease chamber. These nuts do not show in the plates, but correspond to nuts 24, P. 1, in the grease chamber cover at the opposite end of the machine. The studs, which are held by four hexagon nuts, not only hold the outside cast iron cover to the grease chamber, but extend through and into an inside cast iron grease chamber cover. The ball bearings are clamped between these two end covers, and these bearings should never be removed from the armature shaft except it be desired to install a new bearing. Therefore, after having removed the hexagon nuts and the outside cover, using a copper punch and hammer, gently drive the studs inward to loosen the inside cover. Having done this, remove bolts 4, P. 1 (four of them), whereupon you may pull away end bearing bracket 2, P. 1.

No. 8.—To Remove the Ball Bearing at the A. C. end of the armature, follow Instruction No. 7. Having done so you will see on the end of the shaft a nut having in its edge a saw kerf, and in its face the head of a machine screw. This screw acts as a lock nut by compressing the edges of the nut where the saw kerf is made, thus locking the threads to the shaft. Loosen it and remove the nut, which has a right-hand thread. This will release the ball bearing, which may be pulled out. When installing the new ball bearing or replacing the old one, *be sure and get it on the shaft straight or "square."* If you attempt to put it on a slant it won't go, but if started on just right will slip on easily. Having it in place, *set up the lock nut as tight as you can get it,* and then set up the screw in its face, thus locking the nut to the shaft. In replacing end bearing bracket 2, P. 1, proceed carefully, and don't try to force it on over the ball bearing. When you get it exactly right it will slip on without any trouble what-

ever. If it does not do so, that is your fault and *not* the fault of the bracket—you have not got it exactly in the right position with relation to the bearing. If you try to force it on you will probably succeed in ruining the ball bearing. The rest of the process of replacing is simply the reversal of the process of disassembling.

No. 9.—To Remove the Armature lift out all the brushes, 17, P. 2. To do this lift finger 9, P. 3, and pull the brush out, letting it hang by its pig tail so that you will be sure to get it back in the right holder. Next remove bolts 4, P. 1 (four of them). Next remove the four hexagon-headed bolts, 24, P. 1, holding grease cover cap, 22, P. 1, and pull the armature, carrying end bracket, 2, P. 1, with it, straight out at the A. C. end.

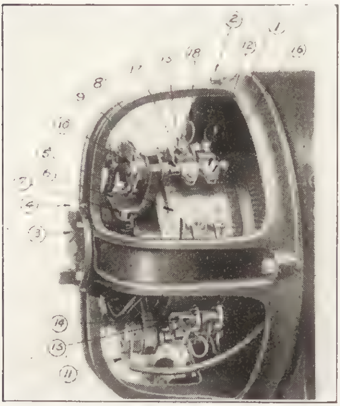


Plate 2, Figure 207.

Caution: *Never lay an armature down flat on anything.* Either stand it on end, or else support it on two chairs or boxes, using the ends of its shaft for the purpose. If you lay the armature itself down on the floor or table you are likely to injure the insulation. The replacement of the armature is simply a reversal of the process of taking it out, doing each step in its turn.

No. 10.—To Remove the Commutator End Bearing Bracket, 3, P. 1, first remove four hexagon headed bolts 24, P. 1, in grease cover cap, 22, P. 1. Next lift out all the brushes. They may be lifted out by raising finger 9, P. 3. Let them hang by their pig tails, so that you will get them back in the right holder. Remove bolts 4, P. 1 (four of them), whereupon the bracket may be pulled away.

Caution: The four hexagon head bolts extend through and hold the plate covering the inside end of the grease chamber. This cover will sometimes stick slightly. Before removing the bolts, but after having backed them out for three or four turns, tap on them lightly with a hammer, in order to loosen the inside grease chamber cover.

No. 11.—To Remove Brush Yoke, 6, P. 2, follow Instruction No. 10, then loosen screw, 7, P. 2, whereupon you may pull away the yoke, carrying all the brush holders.

No. 12.—Brush Holder Stud. Should it ever be necessary to remove brush holder stud, 8, P. 2, it may be done by loosening nut, 10, P. 2, but if you do this, be very careful in reassembling that the insulation, which consists of two mica washers, 9, P. 2, and a mica sleeve around the bolt, be not in any way injured. If this insulation is not perfect, then the whole frame of the machine will be charged with potential. In loosening these parts it will be well to remove nut 10, P. 2, and thoroughly clean the contact between it and the copper clip to which the wire is connected. In reassembling be sure to set up nut 10, *tight,* else you will not have good electrical contact; also it is essential that the lock nut behind nut 10, which holds the insulation in place, be set up tight, else the brushholder stud will vibrate and thus cause trouble.

No. 13.—Brushholder, 12, P. 2, may be slipped off at any time by loosening screw 16, P. 2. Before taking off the brushholder you should make a scratch mark at its end on the stud, so that in reassembling you may get it back in exactly the same position it formerly occupied.

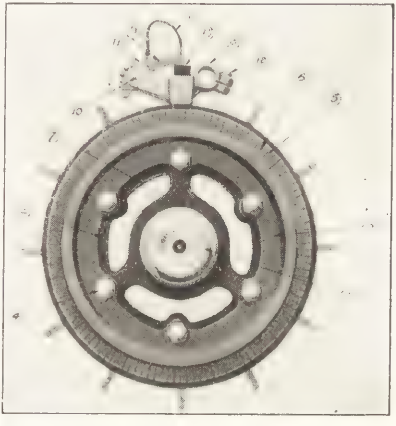


Plate 3, Figure 208.

No. 14.—Care of the Commutator. (See General Instruction No. 8.)

No. 15.—To Install New Brushes. First raise finger 16, P. 1 (shown better at 9, P. 3), and remove the screw holding the end of the pig tail to the brass casting, then lift out the brush, put in the new one and attach its pig tail to the casting the same as the old one was. *The face of the new brush must be ground fitted to the curve of the commutator.* To do this lift out all the brushes you are not replacing, then place on the commutator, sand side out, a strip of No. 1 sandpaper

long enough to extend one and one-half times around its circumference. Lower the new brush on this sandpaper under the pressure of its tension spring, and revolve the armature until the brush is ground down to a proper bearing. It is also possible to lay a piece of sandpaper on the commutator and pull it back and forth, but the other way is the better.

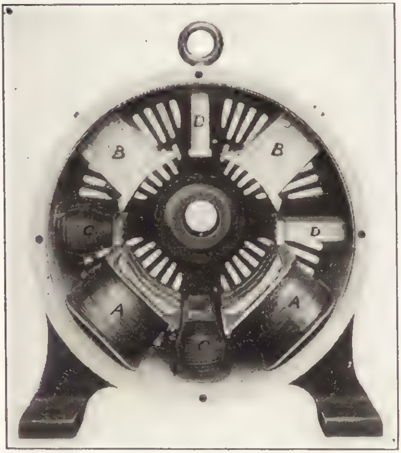


Plate 4, Figure 209.

No. 16.—Heating. (See General Instruction No. 11.)

No. 17.—General Remarks. Plate 3 shows the construction of the brushholder in detail, 14 being the pig tail, 11 the spring which governs the amount of tension supplied the brushes through finger 9, P. 3. Plate 4 shows the pole piece construction, main poles AA being wound and BB not wound. In like manner interpoles or "commutating poles" C, are wound, while DD shows the core of the poles without the windings. The machine is entirely self-contained, and requires no special base. It may either be set on a cement floor and bolted down or on any other reasonably solid foundation, but if installed in the operating room it should be set on a felt pad, as per General Instruction No. 2. This will take up all vibration, make the machine practically noiseless, and there will be no necessity for bolting it down at all.

The efficiency of the machine is claimed by the manufacturer to be between 65 and 70 per cent, depending upon local conditions and the degree of intelligent care given.

The accompanying connection diagrams are quite plain, and may, I believe, be followed without any trouble by the average well-posted operator. Plate 5 shows the various connections for single, two and three phase 110 or 220 volt circuits.

All Hallberg Twentieth Century A. C. to D. C. motor generators are so wound that they may be used either for 110 or 220 volt current, merely by changing the connections as shown in P. 5.

Two-Arc Machine.—P. 6 shows the wiring of the D. C. end, with two projection arcs connected in multiple with each other. By this arrangement arc No. 1 may be operated at any desired amperage between 30 and 60 by moving the handle of the field controller, which has twenty-one

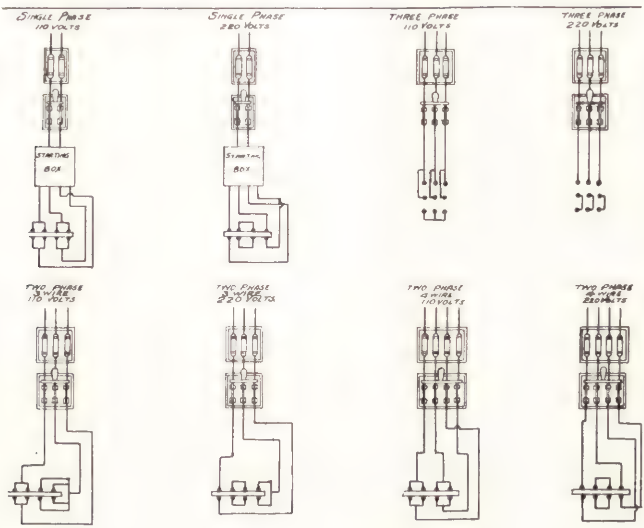


Plate 5, Figure 210.

contacts, supplying twenty-one different current values. When it is desired to start the second arc and fade the first picture into the next, the operating or machine switch on machine No. 2 may be closed, and when the time comes to swing over to that machine its arc is started merely by bringing the carbons together and separating them in the usual manner, which will automatically extinguish the arc of machine No. 1, thus fading one picture into the next. This is a matter which will require some practice, but once it is mastered it is quite possible to secure fair results. But where this plan is used the operator will do well to burn craters on his carbons when there is no picture on the screen. In other words, he should have a supply of burned-in carbons. It will prob-

ably also be found necessary to recenter the upper crater by raising the lamp about one-quarter of an inch before starting the arc. The machine motor must, of course, be started at the same time the arcs are changed over. The manufacturer claims that one of the peculiarities of this generator is that it picks up and steadies its arc almost instantly.

P. 7 shows the machine connected to a single-phase circuit, with an emergency circuit of two economizers which may be put into service merely by throwing over the upper three-pole switch. P. 7 also shows a switchboard upon which is mounted the controller shown in P. 6, by means of which the amperage at the arc may be varied at the will of the operator, or, when two arcs are, to be operated at the same time this controller is used to secure the desired D. C. amperage within the capacity of the machine. The lower three-pole, double-throw switch in P. 7 is so connected that when the handle is to the right, the compound winding on the generator opposes the shunt, which causes the generator to produce constant current for the operation of one arc at a time, in which case no resistance is necessary in series with the arc, the generator having within itself the necessary flexibility to properly control the arc.

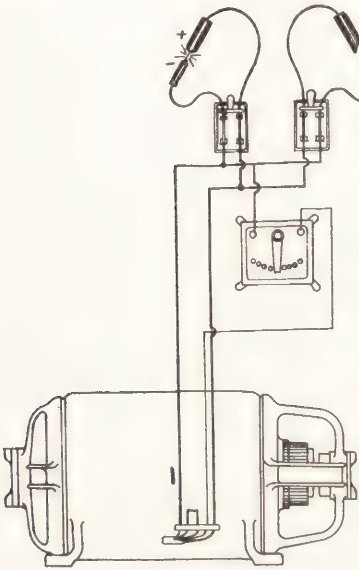


Plate 6, Figure 211.

Examining this switch you will notice that when it is to the right its lower blade short circuits the resistance immediately below it. This resistance is in two units, the same being in multiple with each other, and the negative armature wire from the generator is connected to its center. By this arrangement the current going through either one of the arcs enters the outside terminals of the resistance units

and travels through them back to the negative pole of the generator. This resistance offers a drop of about 5 volts when the two resistances are in parallel with each other and in series with the arc, and it is in some instances found

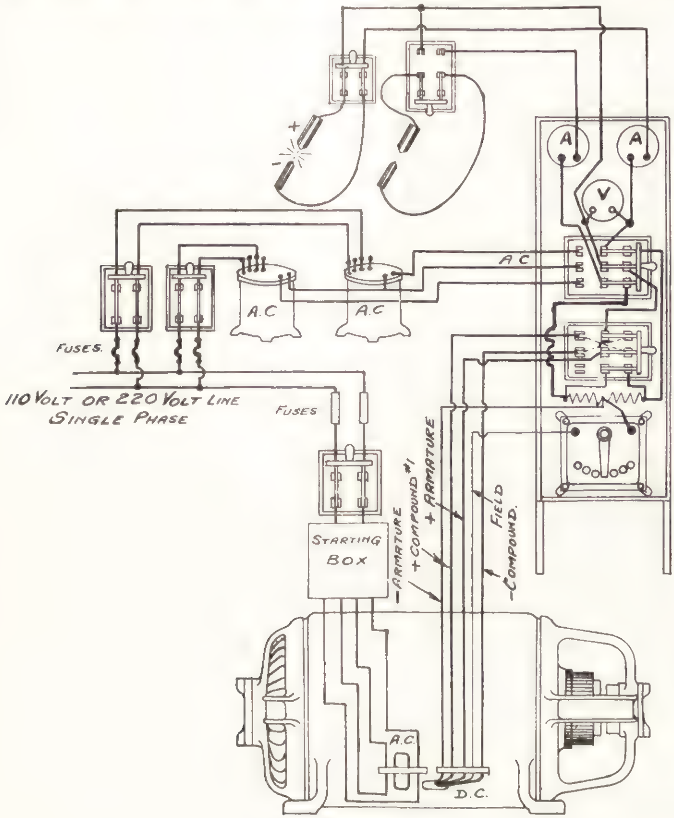


Plate 7, Figure 212.

desirable to leave the resistance in circuit. For highest efficiency, however, there can be furnished an extra switch blade, by means of which the resistance unit can be entirely short circuited when the three-pole switch is to the right for single lamp operation. When the lower three-pole switch

is to the left the compound windings on the generator are reversed and act with the shunt field, which makes the generator a cumulative compound machine, under which condition it produces constant potential. When the lower three-pole switch is to the left the short circuit across the resistance unit is open and the resistance is now connected so that the left-hand half is in series with one of the arcs and the right-hand in series with the other arc. The upper three-pole, double-throw switch is to the right when the generator is working, but should the generator break down it is only necessary to throw it over to the left to cut in alternating current at the arc through the economizers.

A-A, P. 7, Fig. 212, are ammeters, one for each arc, and V the voltmeter. At the top on P. 7, it will be observed that arc No. 2 takes current through a double-pole, double-throw switch. This arrangement is offered as a suggestion where in some instances it is necessary to take extra precaution in order always, under all conditions, to maintain one of the arcs. For instance, in some theatres where the entire projection installation is supplied from the electric company's two or three phase service the house lighting may be on an entirely separate set of mains, with separate transformer and meter on single phase. The house lighting system may be fed from another street, one or more blocks away. In a case of this kind the second emergency connection from the single phase or house lighting service may be brought into one of the machine switches through suitable means of voltage reduction, by the use of one of the sets of terminals on the double-throw, double-pole switch. In P. 7, the lower three-pole, double-throw switch is to the right for one lamp, and to the left when two lamps are being operated.

Mercury Arc Rectifier

General Remarks

THE mercury arc rectifier is a device marketed by two manufacturers, the General Electric Company and the Westinghouse Electric and Manufacturing Company, for the purpose of changing alternating current of standard line voltage to direct current at arc voltage, the reduction in pressure being accomplished by means of an auto transformer which is an integral part of the machine.

In describing the "Principle of Operation," let it be clearly understood that I have sacrificed accurate correctness in

favor of "understandableness." To tell exactly what happens inside of a rectifier tube would be a good deal like trying to explain what electricity is or to explain the reason for the force of gravity. Electrical engineers acquainted with the mercury arc rectifier have various opinions as to exactly what takes place inside the tube, and while I have every respect for the opinion of these eminent gentlemen I am advancing a theory which, while it may be entirely wrong, sounds to me like common sense. In fact I wrote it with two ends in view, viz.: first, to make the matter understandable to the ordinary operator; second, to set forth my view of what ought to take place, simply viewing the matter in the light of common sense. With this explanation the following is submitted:

Principle of Operation.—The mercury arc rectifier consists essentially of a sealed glass bulb, from which the air has

Figure 213.

been exhausted, provided with four terminals, A, A1, B and C, Fig. 213. Within this tube is a quantity of mercury the purpose of which will be explained further on. The two upper terminals A, A1, Fig. 213, are of graphite or other suitable material, and the two lower ones B, C, Fig. 213, are of mercury, the smaller one of the two, C, Fig. 213, being

what is known as a "starting terminal." When the bulb is in a vertical position the pools of mercury in terminals B and C are separated, but when the tube is tilted or rocked sidewise (to the left) these mercury pools are brought temporarily into contact with each other for the purpose of starting the tube into action.

The vacuum bulb, in its active state, contains vapor of mercury, which is a conductor of electricity only under certain conditions. Current will readily pass from either one of the graphite terminals, A, A1, Fig. 213, into the mercury vapor, and, with the circuit completed by the arc, will pass from it into mercury terminal B, and thus on through the arc.

Alternating current, however, changes its direction many times in the course of a second of time, but when the direction of flow seeks to reverse itself and pass from the mercury to the graphite terminals, these terminals offer resistance which prevents the flow, and thus the graphite terminals act as check valves, permitting the current to pass into mercury vapor, but preventing it from passing into the graphite terminals.

The alternating current supply circuit is connected to graphite terminals A, A1, Fig. 213, through an auto-transformer which lowers the voltage to that required at the arc, and as the action is such as will only allow current to flow in one direction, the pulsations of current which pass alternately from terminal A and A1, Fig. 213, into the mercury vapor must, of necessity, pass out of the vapor through mercury terminal B, Fig. 213, which is connected to the arc lamp, and thus we have a continuous, slightly pulsating current delivered at the arc. The pulsations would ordinarily be quite pronounced on the D. C. side, but this matter is taken care of by a feature of the auto-transformer (an integral part of the machine) which serves to "flatten out" or decreas the natural pulsations, so that the current delivered at the arc has a very nearly constant potential value.

Before the bulb starts to rectify, the mercury vapor is absent, and between electrodes A, A1, B, and C there is a vacuum which presents high resistance, and this space must be filled with mercury vapor before current can pass. Once this has been accomplished, however, and current flow has started, it will continue to flow as long as the supply is uninterrupted. Any interruption of the supply, however, even for the shortest period of time, permits the vacuum to re-establish itself and stops the operation of the bulb.

In order to establish the mercury vapor, or conducting medium, the bulb is tilted so that the space between the large and small mercury pools in terminals B, C, is temporarily bridged by mercury, whereupon current passes between terminals B and C through a special circuit provided, directly from the A. C. supply lines. As the tube rocks back to upright position this little mercury bridge between terminals B and C is broken, and in breaking it forms an arc or spark, and it is this arc or spark which creates the initial current carrying mercury vapor and puts the tube into operation. Once operation is started the rectifier will continue to operate indefinitely as long as the current supply is uninterrupted.

The alternating current supply circuit is connected to an auto-transformer or main reactance, the terminals of which are connected to the terminals A, A1, Fig. 213. From terminal B the current passes through the arc and the circuit is completed through a connection to the middle point of the auto-transformer.

In the main, rectifiers consist of: (A) an auto-transformer; (B) a regulating reactance coil; (C) a tilting mechanism; (D) a relay; (E) a dial switch; (F) a switch or other means for connecting the auto-transformer directly to the arc, and, (G) a bulb and its holder.

The reactance coil is for the purpose of giving steadiness to the arc and limiting the current when the carbons are brought together when striking an arc (a dead short circuit) to a value which will not be injurious to the bulb.

Modern rectifiers are so equipped that in case the bulb gives out the operator can switch over to the auto-transformer and continue the show with alternating current, using the auto-transformer as an economizer. Also modern rectifiers are equipped with a dial switch by means of which the operator can instantly vary the amperage within certain limits.

Installation.—Rectifiers are ordinarily received in two separate shipments, one of which, the rectifier itself, weighing several hundred pounds, will probably come by freight. The other, the glass bulb, is carefully packed in a specially made case, and is usually sent by express. In removing the bulb from its crate proceed strictly according to directions in loosening the crate, after which carefully lift out the bulb. It will be in an inverted position. Turn it slowly over and carefully let the mercury run down into terminals B, C. In rolling the mercury should make a sharp, cracking sound, which is an indication that the tube is in good condition.

The rectifier should not be located directly in the operating room unless there be some means provided for covering the bulb so that its light will not shine in the room. Light in the operating room is highly objectionable. One very good method is to install the rectifier in an adjoining room and cut a space through the wall just large enough to admit the front panel of the rectifier. This allows the operator to have access to the switches for the purpose of varying the amperage, or changing over to A. C., and at the same time excluding the light from the room.

Some managers place the rectifier in such position that it can be seen from the front of the theatre where the weird greenish light given off by the bulb attracts considerable attention. As a general proposition, however, the modern rectifier which allows of changing amperage by means of a switch should be so located that the operator can reach these switches without leaving the operating room.

There is no vibration and no noise except a humming sound which emanates from the transformer. Care should be exercised that there is no sheet metal near the machine, since if there is the transformer would probably set up vibration therein and thus create more or less objectionable noise.

Comparative Results.—Experiments made by Simon Henry Gage and Henry Phelps Gage, Cornell University, have shown that the losses through the pulsation of the current with the mercury arc rectifier are but very slight. A mercury arc rectifier using 40 amperes at 52 volts gave 12,150 C. P., whereas straight D. C., 40 amperes at 51 volts, with the same carbon set only gave 12,350 C. P., a difference of about 200 C. P.

Tubes should never, under any circumstances, be operated above their maximum capacity.

On the following page appears a chart indicating the various troubles one is likely to encounter when operating a rectifier, together with the most probable cause or causes of each. A careful study of this diagram ought to be of much value to users of rectifiers. With this chart and the detailed instructions contained in this book, plus a fair supply of "horse sense," I believe any operator ought to handle a rectifier without any serious difficulty.

- TUBE DOES NOT START.
  - See if there is voltage and if it is up to normal.
    - TUBE DOES NOT TILT.
      - No current at tube terminals.
        - Current at switch—Fuses blown.
        - No current at switch—Line voltage off.
      - Relay contact not closed.
        - Friction or bent stud.
        - Relay contact is poor.
        - Tilting circuit open.
        - Secondary coil of magnet short-circuited.
    - TUBE TILTS.
      - Amalgam bridge between electrodes—Install new tube.
    - TUBE TILTS.
      - D. C. circuit open.
        - Lamp circuit open.
        - Carbons not making good contact with each other or with the lamp jaws.
- TUBE TILTS.
  - Does not return to vertical.
    - Lead on starting anode broken or loose.
    - Mercury pools do not make contact.
      - Adjust tube; it does not tilt far enough.
    - Friction in tube holder.
  - Returns to vertical without flash after repeated tilts.
    - Tube is defective.
    - Tube has lost its vacuum.
      - New tube.
  - Flashes and goes out.
    - Lead to positive electrode anode loose or broken.
- Tube continues to tilt after starting.
  - Relay does not open the circuit.
    - Winding short-circuited, friction or bent stud.
- Tube goes out.
  - Lamp carbons separated too far.
- Tube tilts feebly.
  - Voltage of circuit low.
  - Frequency of current not right
  - Friction in tilting mechanism.
  - Tube is too heavy at bottom.
- Outfit is noisy.
  - Reactance coil loose on frame.
  - Reactance coil air gap not wedged tight.
  - Cover vibrates.
  - Operating room floor vibrates—set outfit on felt pads.
- Arc is noisy.
  - Carbons too hard—use softer ones.

NOTE.—When proper vacuum exists the mercury gives off a sharp clicking sound when it is run from one end of the tube to the other. Absence of this sound and the presence of air bubbles show loss of vacuum.

Tube may be defective by short-circuiting between starting anode and cathode. When in this condition it is badly blackened.

GENERAL ELECTRIC MERCURY ARC RECTIFIER

The General Electric Company, Schenectady, N. Y., manufactures rectifiers for use on projection circuits in three capacities, 30, 40 and 50 amperes. The General Electric

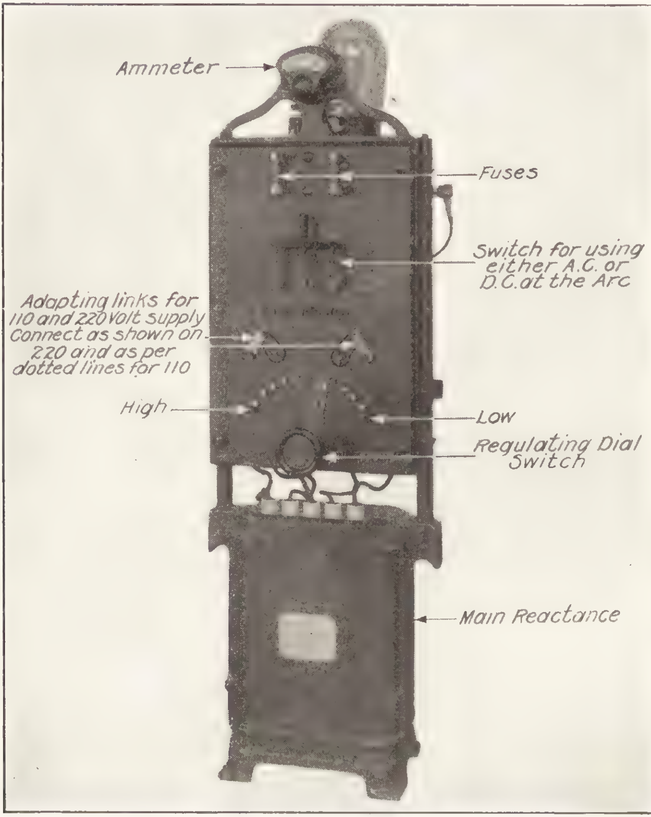


Plate 1, Figure 214.

rectifiers may all be used on either 110 or 220 volts. They are made for 50 to 133 cycle circuits, and for 25 to 40 cycle circuits. The machines are of the panel or switchboard type

in that the front of the machine consists of a slate switchboard 1½ inches thick and 16 by 24 inches in size, finished in dull black and mounted above the main reactance, as per Plate 1. On the front of this board are mounted the fuses, a three-pole, double-throw switch, the adapting links, the dial switch, and the ammeter and voltmeter, one or both, provided they are ordered; ammeters and voltmeters only

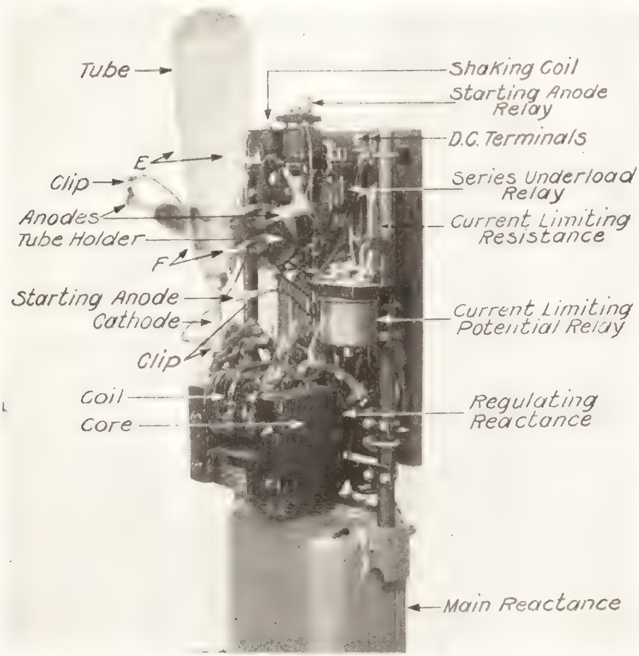


Plate 2, Figure 215.

being sent when specially ordered. On the back of the board or panel are mounted the regulating reactance, the various relays, current limiting resistances, tube, etc., as in Plate 2. The general appearance of the machine is pleasing to the eye. It is not excessive in weight, and occupies but little floor space. The G. E. rectifiers are entirely automatic in their operation. All that is necessary to start the rectifier is to close the A. C. supply and machine table switches and

bring the carbons in the lamp together, whereupon the rectifier automatically will begin business. The size of rectifiers to be used depends upon: (a) area of screen surface to be illuminated; (b) character of screen surface; (c) the amount of light there is in the auditorium. (See Amperage, Page 157.)

The Instruments (when ordered) are of the D'Arsonval or permanent magnet type. When both ammeter and voltmeter are supplied the two are mounted together in one case, and the whole placed on a bracket above the panel. The instruments are accurate and are connected in the secondary, or D. C. side, hence show the voltage and amperage at the arc. They always should be ordered when a rectifier is purchased. I myself would prefer that they be mounted on the wall in front of the operator, rather than on the rectifier, which may not be placed directly under the operator's eye, and these instruments may be removed from the rectifier and so mounted if desired.

Fuses.—Fuses of greater capacity than those furnished with the rectifier should never be used. For a 30 ampere rectifier use 35 ampere fuses; for 40 or 50 ampere machine use 55 ampere fuses.

From Direct Current to Alternating Current.—In Plate 1 we see a triple-pole, double-throw swicth in the center of the panel. This switch is for the purpose of immediately changing from D. C. to A. C., using the main reactance as an economizer in case anything should happen to the tube, or in case it should be, for any reason, necessary to use A. C. at the arc. The switch as shown in Plate 1 is set for D. C.; by throwing it over, downward, the D. C. rectification is stopped and alternating current is supplied at the arc. If the switch is thrown over to A. C. it may be found that the alternating current is too low, in which case lead 3, Plate 3, may be moved along studs 1, Plate 3, until the right current is obtained. Do not use over 60 amperes. *It should be borne in mind that the rectifier is built primarily for changing A. C. to D. C., and, while its main reactance may be used as an economizer and provision is made for that purpose, that provision is only designed for emergency.* The machine should, so far as possible, be used exclusively as a rectifier.

Connecting or Adapting Links, Plate 1, are for the purpose of adapting the rectifier to either 110 or 220 volt supply. In order to change from one to the other all that is necessary is to change the links as indicated in Plate 1. For 220 volt

current they should be connected to the upper stud and the two outer lower studs; for 110 volt current they should be connected to the two upper and the two inside lower studs.

The Dial Switch has eleven contacts, Plate 1, which are connected to eleven taps on the regulating reactance, Plates 3 and 5. This connection is clearly shown in Plate 3, in which the regulating reactance, 2, has been dropped down to show the connections. This switch is for the purpose of regulating the amperage at the arc, and any amperage within the capacity of the rectifier may be instantly had by merely moving the switch to the left to raise and to the right to lower, as per Plate 1.

The Main Reactance, Plate 1, is nothing more or less than a very well constructed auto-transformer, the insulation of which is calculated to withstand many times the normal operating voltage. These reactances are given the vacuum compound treatment, which is the best known resister to moisture, as well as a high class preservative. The main reactance has three distinct functions: (a) It adjusts the voltage of the alternating current to the proper value to apply to the anodes of the tube to secure the proper D. C. voltage at the lamp; (b) it supplies a neutral point between the alternating current lines and forms the negative of the direct current lines; (c) by its reactance it keeps the rectifier tube in operation while the current passes through the zero point of the alternating current wave.

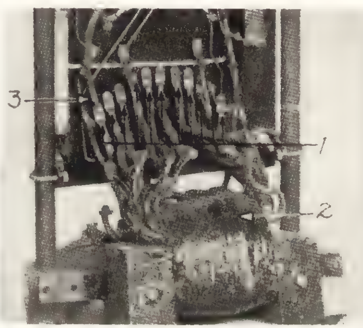


Plate 3, Figure 216.

The Regulating Reactance.—The regulating reactance, Plates 2 and 3, is nothing more or less than a choke coil with eleven or more taps taken off at certain points along the winding, these taps being connected to an equal number of contacts or studs of the dial switch, P. 1 and 3, so that the alternating current can be choked back or reduced to a value just sufficient to give the desired amperage at the arc. It produces practically the same effect as would a rheostat, but with far less waste of power. By manipulating the

dial switch any D. C. amperage within the range of the rectifier is made instantly available.

The Tubes.—The rectifier tube has already been described under "General Remarks," and the General Electric tube is shown in Plate 2 and Fig. 213.

Tubes should be handled with care, and in uncrating a new tube the instructions which come with it should be closely and

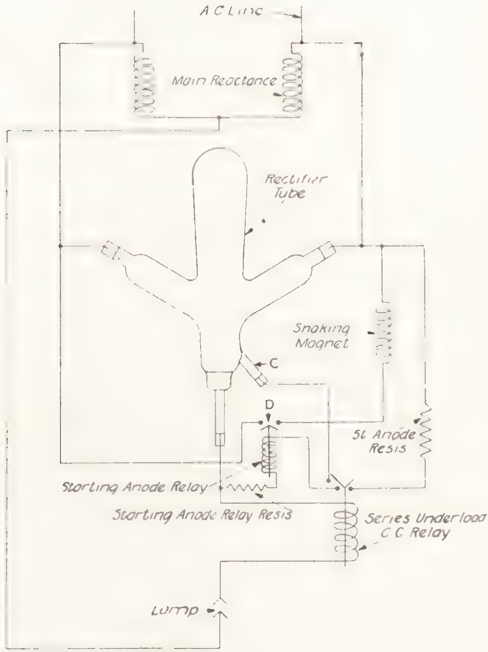


Plate 4, Figure 217.

carefully followed. See General Remarks, under caption "Installation," Page 431.

Plate 4 shows a rough diagram of the connections of the General Electric mercury arc rectifier; all parts of the rectifier are shown diagrammatically *without reference to their actual position with relation to one another when mounted on the rectifier,* the idea being merely to illustrate the method employed in starting.

By referring to Plate 4 it will be seen that three coils are used for starting, viz: a shaking magnet, a series overload relay, and a starting anode relay, the latter, which is normally open, but picks up when the carbons of the lamp are brought together, thus closing the shaking magnet circuit, see D, Plate 4, whereupon the shaking magnet pulls the tube over to one side, or, in other words, "rocks" it, thus allowing the mercury in cathode B, Fig. 213, to bridge over and form a connection with the mercury in starting anode C, which shunts the current from the starting anode relay D, Plate 4, circuit, and operates to demagnetize its coil, thus allowing its plunger to fall and open the shaking magnet circuit, whereupon the tube, by its own weight, rocks back into vertical position, thus breaking the mercury bridge between anode C and cathode B, Fig. 213. After the tube has started operating, and the arc has been struck, the series underload relay, which is connected in the D. C. circuit, picks up, thus cutting the starting anode relay and shaking magnet entirely out of circuit. If the tube does not start at once the shaking magnet continues to rock the tube until it does.

Installation.—After the rectifier set has been uncrated and placed in its operating location (See "Installation," Page 431), the tube should be placed in the holders E, F, as per Plate 2. This is accomplished by pressing the narrow part of the tube, just above anode arms A, A1, into upper clip E, Plate 2, carefully lowering the tube until anodes A, A1, rest on the lower clips, F, Plate 2. Having got the tube in place, you will find four wires covered with a sort of glass bead insulation, these wires terminating in brass spring clips, Plate 5. Connect the two upper ones (either one to either anode) to anodes A, A1, the small lower one to starting anode C, Fig. 213, and the large lower one to cathode B, Fig. 213, as shown in Plate 2. Next connect the A. C. supply lines to the two terminals (marked A-C) at the upper left hand corner of the panel—that is to say, the left hand corner as you stand facing the tube on the back side of the machine.

These terminals are shown on Plate 5. Next connect the positive D. C. terminal, Plate 2, marked + to one side of the machine table switch, and through the machine table switch to the upper carbon arm of the lamp, and connect the negative (marked —) D. C. terminal to the other side of the machine table switch, and through it to the lower carbon arm of the lamp. The D. C. terminals will be seen, properly labeled in Plate 2. Connect the adapting links in the front

of the panel according to the voltage of your alternating current supply, as per Plate 1. Having accomplished all this, with the triple-pole *switch closed in the upper position,* as per Plate 1, and with the A. C. supply and D. C. machine table switch closed, the rectifier is ready to start.

Operation.—To start the rectifier bring the lamp carbons together, whereupon the tube will rock, and usually start at once. As soon as it starts slowly separate the carbons to the usual distance when using D. C., say approximately one-fourth of an inch for ordinary amperage. When the carbons have been separated far enough that the voltage between them is about 45, the potential relay, 4, Plate 5, (if it is a 40 or 50 ampere rectifier; there is none on the smaller size) will operate and short-circuit the current limiting resistance, 3, Plate 5, thus increasing the arc current to whatever value the dial switch is set for.

Caution.—When you first begin to use a rectifier be sure that the potential relay operates. If it does not the current limiting resistance, 3, Plate 5, will heat, and whereas it would be difficult to actually burn it out still damage might be done to the insulation of the surrounding wires.

The operator can tell when this relay acts as follows: When the carbons are first separated the current will be comparatively weak, and when the relay acts there will be a sudden increase in brilliancy at the spot. The knack of detecting the action of the relay can be acquired by starting the arc several times and slowly separating the carbons until the relay picks up. In doing this it would be well to have a man by the rectifier to tell you when it does pick up, if the rectifier is at a distance. Half a dozen trials ought to show just how the thing works, so that you will have no further trouble in detecting its action. To stop the rectifier, open either the A. C. or D. C. switch or the triple-pole switch.

Operating Two Arcs from One Rectifier.—When it is desirable to operate two arcs from one rectifier the General Electric Company will furnish two resistances equipped with contactors, one to be used in series with each lamp. These resistances consist of a number of coils, inclosed in a ventilated sheet metal box, for mounting on the frame of the machine, or standing on the floor beside the machine. Diagram, Plate 6, shows the resistances connected in the lamp circuits. The operation of fading one reel into another is briefly as follows: Assume the operator to be running a

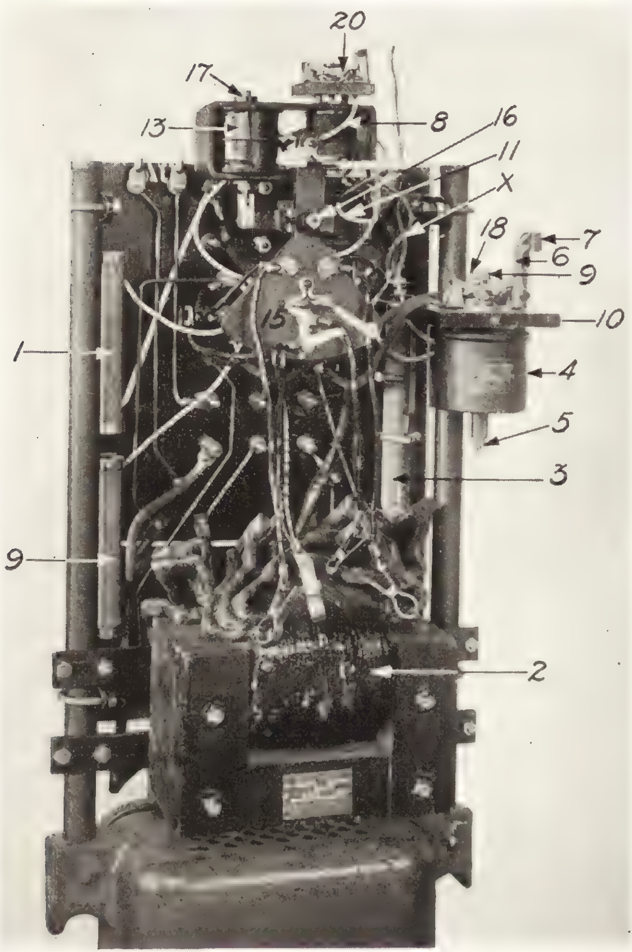


Plate 5, Figure 218.

picture machine on No. 1, in which case the contactor is closed by hand (cutting out the resistance which is normally in circuit) at the start and held in this position by a magnet coil. At any time while this reel is running the operator (leaving the contactor on arc No. 2 open) may start machine No. 2 at about 10 amperes, thus allowing the carbon to be warmed up on No. 2, while the reel is still being run on machine No. 1. At the end of the reel on machine No. 1, machine No. 2, with arc burning with resistance in circuit, is then started; the contactor is closed, thus cutting out the resistance and boosting the current to normal, at the same time short-circuiting the arc of machine No. 1, putting it out, which stops the current flowing in resistance box No. 1, thus opening the contactor. The resistance cannot be accidentally left out when the second arc is struck. When the first arc is short-circuited the contactor opens, which automatically *cuts in* the resistance. These resistances prevent overloading the rectifier. Remember that the *resistance is in* when the contactor is *open.*

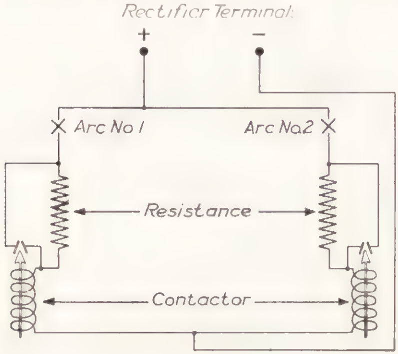


Plate 6, Figure 219.

I would recommend to managers the purchase of one of the larger rectifiers. The modern tendency is to use high amperage and project a brilliant picture. The first cost will be greater, but it is worth the money. This, however, may be qualifie by saying that in very small towns where the possible patronage is limited and every penny of expenditure has to be closely scrutinized it might not be advisable to go above the 30 ampere size.

Explanations.—We have told you in a general way of the action of the rectifier. Now let us examine into its "chronometer balance and cylinder escapement" and see if we can find out what it's all about.

Note: You need not be afraid to perform any of these various operations in case of necessity; just follow the directions and *use a little common sense,* remembering where each part goes,

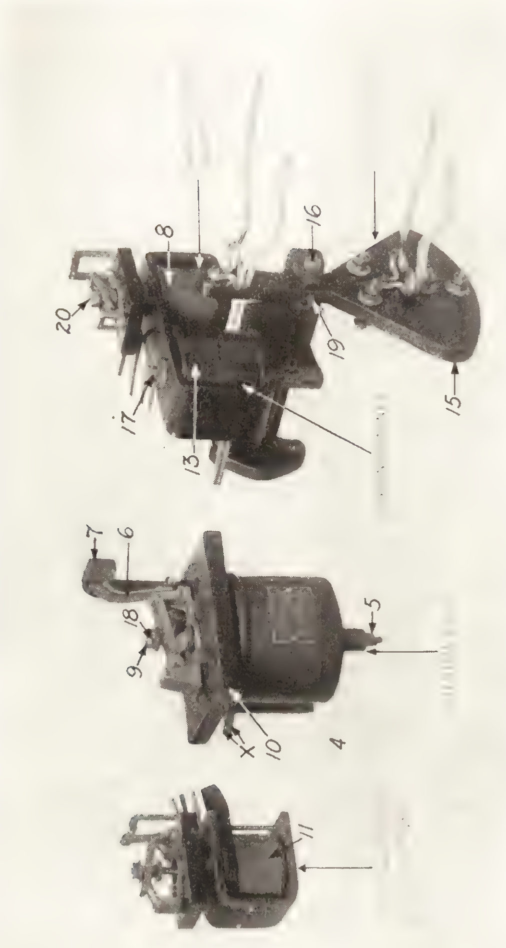


Plate 7, Figure 220.

or, if necessary, attaching a labeled tag to it as you remove it. There is no mystery about these things. All too often the operator hesitates to attempt the making of repairs through fear of being unable to get the thing back into shape. The rectifier is strongly made, and its parts are very simple. I repeat: Follow the instructions here given, supplementing them by ordinary common sense, and you will be extremely unlikely to have any trouble.

The current-limiting resistance 3, Plate 5, consists of a strip of resistance metal, wound in spiral form, covered with insulating material and supplied with contacts at either end. Resistances 1 and 9, Plate 5, are made of wire wound on asbestos, and the whole dipped in an insulating material.

The purpose of current-limiting resistance 3, Plate 5, is as follows: When the carbons are brought together the effect is, to all intents and purposes, to form a short circuit, which would have the effect of sending a heavy rush of current through the arc circuit. Resistance 3 in effect takes the place of the resistance offered by the arc after the carbons are separated. This resistance is automatically cut into circuit when the plunger of relay 4, Plate 5, is down; or, in other words, when relay 4 is "open." When the carbons are opened and the arc struck the effect is to add the resistance of the arc to the resistance offered by current-limiting resistance, 3, and thus raise the voltage of the lamp circuit. When this voltage reaches a certain point (about 40 volts) the energy of the magnet of relay 4 becomes sufficient to raise plunger 5, Plates 5 and 7, and bring blade 6, Plates 5 and 7, into contact with block 7, Plates 5 and 7, thus short-circuiting current-limiting resistance 3, and raising the D. C. amperage.

Should relay 4 at any time fail to act it is most likely that plunger 5, Plates 5 and 7, is stuck, which might be caused by a grain of dirt or from some other cause. This plunger may be removed from the magnet by pulling out split key 18, Plates 5 and 7, and, holding stationary nut 9 at the top of the plunger, unscrew plunger 5 by turning its lower end. Having removed the plunger and ascertained the cause of its sticking, it may be replaced, and when you are able to get split key 18 into its hole you may know that the plunger is in the proper location. *In replacing nut be sure to get it right side up.* If you can't get the split key in the chances are that you haven't the nut right side up. Also, in replacing nut 9, *be sure to get the two washers underneath it in place.*

It will be well to clean the contact between block 7 and blade 6, Plate 7, say, once a month with 00 emery cloth.

Should anything happen to seriously injure the parts on top of relay 4, Plate 5, as, for instance, something falling on them and smashing the whole thing so badly that it could not readily be put back into shape, then new parts can be obtained from the factory. In order to remove the old parts, take out three screws in the top of block 10, Plate 7, the same being countersunk into the block—two on one side of the brass parts and one on the other; disconnect the wires from the parts; take out plunger 5, as per former directions, and you can then lift the block off and replace it with a new one. The block should be ordered complete with the parts assembled. Should it ever become necessary to remove the coil of relay 4, Plate 5, first proceed as before directed, and remove block 10, Plate 7. Having removed this block you will see three screws in the top of the coil casing. Take out these screws and disconnect the two wires which lead from the coil, and disconnect wires (two of them) X, Plate 5. You may then lift the coil out, and replace it with a new one if necessary.

The instruction given for removing the top and the coil of relay 4, Plate 5, applies equally to all the other relays; just remove the screws in the top of the block (the screws are countersunk in all cases), disconnect the wires, remove the relay plunger, and the whole thing comes off.

Starting anode relay resistance 1, Plate 5, is in series with starting anode relay 8, Plate 5 (also see Plate 2), the purpose of this resistance being to limit the amount of current flowing through the coil of the relay. It is connected permanently into the circuit of the relay magnet coil.

Resistance coil 9, Plate 5, is connected in series with the contacts of series underload relay 11, Plates 5 and 7. (You cannot see this relay in Plate 5. It is under arrow head 11). This resistance is *not* in series with the relay coil, but serves to limit the flow of current through the starting anode, Plate 2. But for this resistance the flow of current through the starting anode would be so heavy that there would be liability of damage to the tube.

Resistance coils 1 and 9, Plate 5, may be removed simply by pulling them out of their clips as you would a cartridge fuse. Resistance coil 3 may be removed by disconnecting the wires attached to it, and taking out the screw which holds the carrying clip to the panel.

Shaking Magnet.—The action of the rectifier is made

automatic by means of shaking magnet 13 and relay 8, Plate 5 and 7. These magnets, therefore, of course, fill a very responsible position. Part 15, Plates 5 and 7, is so made that it brings the tube back to the vertical position after it has been rocked by the action of the shaking magnet, through force of gravity. Should the tube at any time fail to rock to the vertical position, it is most likely due to friction in spindle 16, Plates 5 and 7. This friction may be overcome by means of a drop or two of oil on the bearing surfaces, just behind the nut on the end of the bolt and at the back of the spindle. It is also possible that dirt may work in beside plunger 17, Plates 5 and 7. This plunger may be removed by taking out the bolt in the fork at its lower end, and driving out the small pin in nut 17 at the top of the plunger. The plunger can then be dropped down enough to clean it.

Should plunger 20 of relay 8, Plates 5 and 7, fail to work, it may be taken out and examined by removing the split key at its upper end and pulling the plunger out at the bottom.

Should the rectifier at any time fail to act, the first thing to look at and test will be your fuses, including those on the front of the panel. Don't try anything else until you have *tested* the fuses. It is quite possible you may get a spark at the carbons of the lamp when one of the fuses is burned out.

WESTINGHOUSE MERCURY ARC RECTIFIER

In Plate 1 we get a view of the front of the Westinghouse Mercury Arc Rectifier designed for use on projection circuits. This machine is built in 30, 40 and 50 ampere sizes, the general design, characteristics and appearance being the same for all.

Each outfit consists of a cast iron main frame on which is mounted (a) an auto-transformer, L-L, Plate 3; (b) reactance coil, Q, Plate 3; (c) a tilting mechanism, B, D, K, P, Plate 2; (d) a relay, I, Plate 3; (e) a five-point dial switch, Plate 1, and E, F, G, H, I, Pl te 2; (f) adapting links, Plate 1; (g) a tube and tube holder, 24, 25, 26, Plate 4, all inclosed in a perforated sheet steel cover. The machine presents a neat, compact appearance and occupies but little floor space.

In Plate 2, we have a view of the rectifier with the perforated sheet steel cover, the cover of the dial switch and the tube removed. At the bottom, in the corner, is the tilting magnet, P, the operation of which is very clearly shown. When magnet P is energized, its plunger, K, moves downward

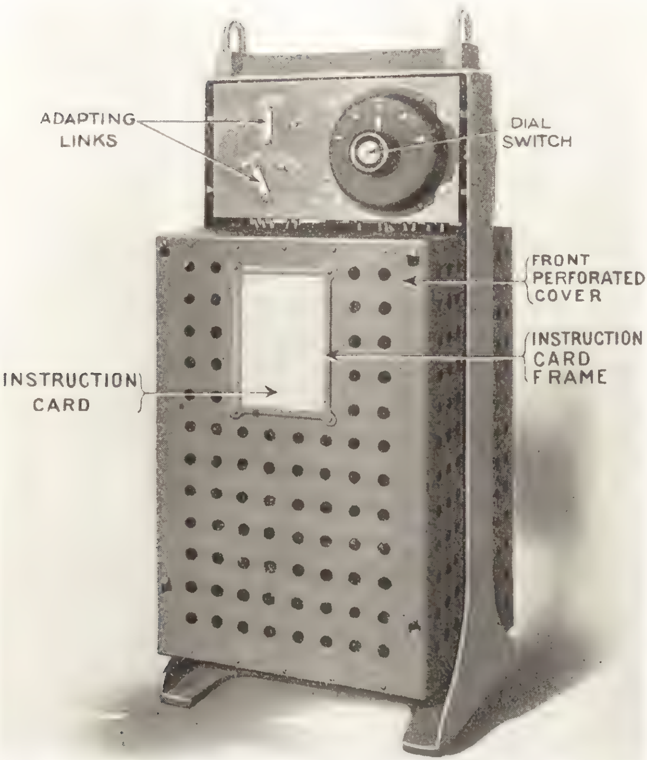


Plate 1, Figure 221.

and tilts or rocks the tube. The construction of the dial switch is also very clearly shown, the round buttons, E, being dummies, over which switch contact fingers G slide from one wide contact, F, to another. At the bottom are four wires, L, M, N, O, coiled up and terminating in brass spring clips. These are the leads which connect to the anodes and cathodes of the tube, as per 9-9-12-29, Plate 4.

In Plate 3 we have a rear view of the outfit, showing, near the bottom, the reactance Q, and above it the auto-transformer L-L. In Plate 3 we see at the left the D. C. leads, A, B, which connect to the arc lamp circuit, the inside one, A, being the negative and the outside or left hand one B, the positive. The positive must, of course, connect through the machine table switch to the top carbon arm of the lamp, and the negative through the machine table switch to the bottom carbon arm of the lamp, The A. C. leads, H, are seen in Plate 3 at right hand side. These leads connect directly, through a switch and fuse, to the alternating current supply. In the center, at the top of Plate 3, is relay magnet 1, the purpose of which will be explained further on.

The Auto-Transformer, L-L, Plate 3, consists of an iron core with a winding of heavy copper wire. It is similar to an ordinary transformer, except that its connections are such that in effect it has only one winding, whereas the ordinary transformer has two, viz: a primary and secondary. Its function is to change the voltage of the A. C. supply circuit to the pressure required at the arc. The center point of the winding also forms the negative terminal of the arc circuit, as per 3, 4, 4, in diagram, Plate 5. (See Fig. 169, Page 358.)

Reactance Coil.—The reactance coil, Q, Plate 3, is similar in appearance and construction to a transformer. It is connected into the alternating current circuit for the purpose of limiting current flow when the carbons are brought together to strike the arc, to a value that will not be injurious to the tube; also it operates to insure steadiness of the arc and to prevent any wide fluctuations of the current when the length of the arc is changed. The general effect is to make the arc much easier to handle.

Tilting Mechanism.—Each rectifier is provided with an automatic tilting device, consisting of parts B, D, K and P, Plate 2. This device is so connected that the closing of the carbons energizes magnet P and thus causes the tube to tilt, which makes the rectifier a self-starter. The mechanism is operated by magnet P, Plate 2, the pull of which is

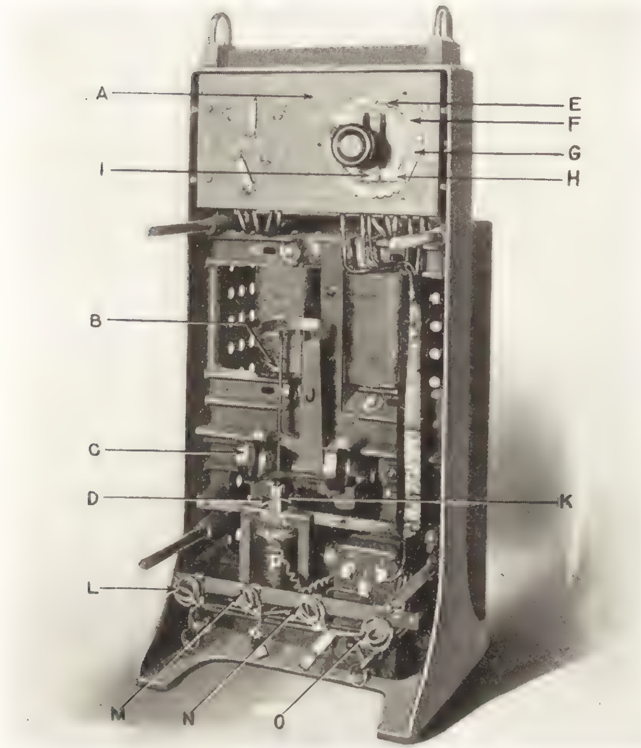


Plate 2, Figure 222.

A, mounting screws for relay; B, upper bulb spring holder; C, lower bulb spring holder; D, brass guide for tilting rod; E, dummy contacts; F, contacts; G, contact finger; H, contact arm; I, insulating support for contact; J, bulb holder casting; K, tilting magnet plunger; L, M, N, O, wires having spring contacts at end to connect to tube anodes and cathodes.

applied to the tube by coil spring B, Plate 2, as shown. A spring is used instead of a rod in order to prevent the tube from being subjected to unnecessary and violent shock.

The Relay, 1, Plate 3, is another magnet, used to operate the contacts which open the tilting magnet circuit when the arc is started, thus preventing the tube from tilting at any other time. But for this cutout the tilting magnet would continue to operate, and the tube would be tilted, or rocked continuously.

The Five Point Dial Switch, Plates 1 and 2, is used to change the connections to the reactance coil in such way as to vary the arc current to any desired value within the limits of the machine. This switch, as its name indicates, gives five different values of current, and the change may be made from one point to another without breaking the arc.

The Upper Adapting Link, 17, Plate 4, is for the purpose of changing the connections to the reactance coil so as to provide proper voltage adjustment at the arc for different supply circuit voltages. In other words, the A. C. supply may be 220 or 110 on the face of it, whereas the actual pressure in the theatre, owing to drop in line, etc., may be anywhere between 210 and 230, or 105 and 115 volts. By means of this link it is possible to provide for these variations and make a connection suited to the actual voltage, which easily may be determined by using an A. C. voltmeter. If a voltmeter is not available the lighting company should be requested to make the test.

The Lower Link Connector, 18, Plate 4, is used in emergency, to transfer the arc from the tube circuit to direct operation on the alternating current circuit, in case the tube should fail or something else happen to the rectifying side of the machine. For direct current operation (rectification) this link should be placed so as to join the lower of the three terminals and the upper right hand terminals, marked "D. C. Arc"; for alternating current operation the link should join the lower terminal and the upper left hand terminal marked "A. C. Arc." Be sure that the wing nuts are well tightened so as to clamp the links firmly.

The Tube is a glass vessel into which a small amount of mercury has been placed, and from which all the air has been removed, causing a vacuum. The general characteristics of its operation have been described under "General Remarks," Page 428. It has four terminals, the upper ones being the graphite anodes, the smaller, lower one the starting anode

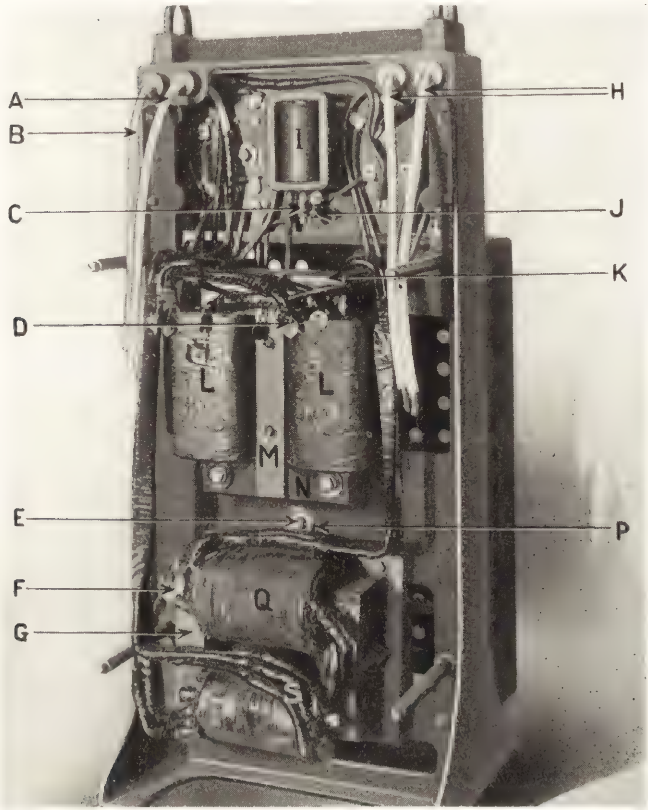


Plate 3, Figure 223.

A, positive D. C. lead; B, negative D. C. lead; C, relay contact disc; D, transformer lead tags; E, rear end of bulb holder shaft in ball bearing; F, reactance lead tags; G, fibre clamping blocks for reactance coil; H, A. C. leads; I, relay magnet; J, relay contact stud; K, transformer iron; L, transformer coil; M, clamping block for transformer iron; N, mounting bolt for transformer; P, cotter pin; Q, reactance coil; R, reactance iron; S, reactance coil leads.

and the large lower one the cathode; both the two lower are of mercury. These various terminals are connected to coiled leads L, M, N, O, Plate 2, by means of brass spring clips, as at 9, 9, 12, 29, Plate 4.

Installation.—The rectifier will be received in two shipments. The glass tube, carefully packed in a special crate, is usually sent by express, whereas the remainder of the outfit, being the completely assembled rectifier (except the tube) all ready for operation, will probably be sent by freight. When the outfit is received, remove it from its case and place in the location selected. Remove the perforated sheet steel cover and connect the A. C. feed wires to rectifier leads H, Plate 3, through a line switch and fuses, as per instructions mounted on front cover of the rectifier. Connect leads D — and C + to the machine table switch with the positive (+), B, Plate 3, connected to the top carbon arm and the negative (—), A, Plate 3, connected to the lower carbon arm. Open the crate containing the tube by removing two screws from the center of each side. Lift the outer portion of the crate away, which will leave the tube suspended from the inner portion of the crate. Loosen the linen tape and lift the tube carefully from the holder. Turn the tube upside down, slowly and very carefully, making sure that the mercury runs slowly into the two bottom terminals. The mercury in a tube that is in good condition should make a sharp metallic click when passing from one end of the tube to the other. Grasp the tube firmly in both hands, the right at the extreme top, and the left grasping the mercury terminals, and, guarding carefully against collision, slide the tube into the lower spring clips of the tube holder, taking care that the springs do not cause the tube to slide into the tube holder with a jar.

Be very careful not to allow the smaller mercury terminal to strike the tube holder, or any other object, as it is quite easily broken. After the lower part of the tube is properly placed, push the top part gently back into the upper spring. If it becomes necessary to remove the tube, as in case of changing location of outfit, the same method of handling should be followed. Connect the tube leads (that is, the flexible wires attached to the terminal board below the tube marked L, M, N, and O, Plate 2) to the tube, as shown at 9, 9, 12, 29, Plate 4. The wires may easily be traced in Plate 4. Connect wire 4, Plate 2, to the upper left hand tube terminal, 9, Plate 4; the lead M to the small lower tube terminal, 29, Plate 4; lead N to the large lower terminal, 12, Plate 4, and

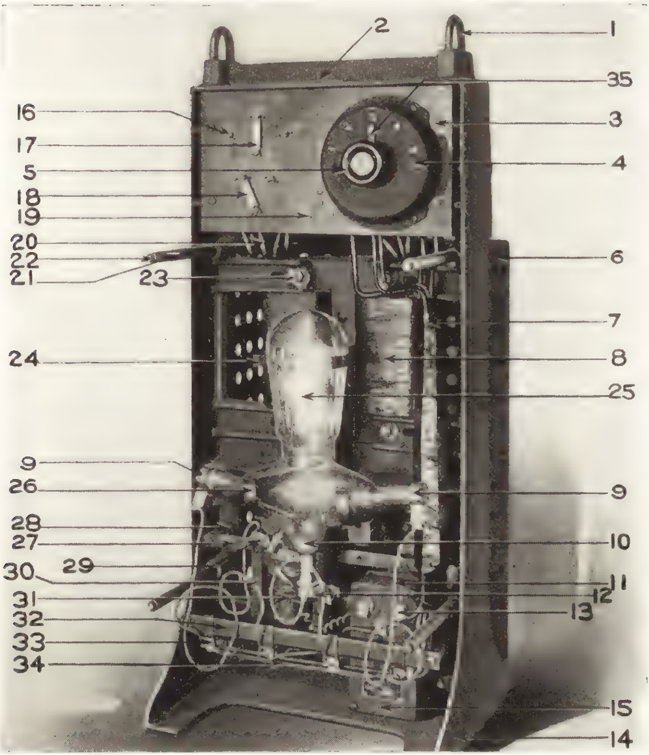


Plate 4, Figure 224.

1, lifting lug; 2, name plate; 3, mounting bolt for slate panel; 4, cast iron cover for dial switch; 5, dial switch handle; 6, rear perforated cover; 7, cable containing leads; 8, transformer; 9, spring clip on side terminal of bulb; 10, mercury pool in bulb; 11, lead to side terminal of bulb; 12, spring clip on large lower terminal of bulb; 13, resistance box terminal; 14, main cast iron frame; 15, resistance box; 16, stud for link connector; 17, upper link connector; 18, lower link connector; 19, end of relay contact stud; 20, transformer leads; 21, stud for front perforated cover; 22, bolt for front perforated cover; 23, mounting bolt for transformer; 24, upper bulb holder spring; 25, bulb; 26, lower bulb holder spring; 27, mounting strap for tilting magnet and resistance box; 28, lug for tilting magnet and resistance box; 29, spring clip on small lower terminal of bulb; 30, tilting magnet frame; 31, tilting magnet coil; 32, terminal board; 33, connector on terminal board; 34, wiring from terminal board; 35, dial switch pointer.

lead 0, the last one, to the right hand upper terminal, 9, Plate 4. The upper link connector on the slate panel at the top of the outfit should now be connected to suit the voltage of the supply wires, which should be determined by actual test with a reliable voltmeter. It may be noted in this connection that the voltage for which the link is set should be tested when the rectifier is in actual operation, since the voltage of the line may decrease with the added load. It is unlikely that once this connection is properly made it ever will be necessary to change it. The outfit, without any further adjustment, is now ready for operation.

Plate 5 shows the wiring diagram for the three types of the Westinghouse rectifier. These diagrams are, I believe, of questionable value to the average operator. However, there are a goodly number who will be able to make use of them. The upper one is for the 30 ampere, 110-220 volt, the center one for the 40 ampere, 110-220 volt, and the lower one for the 50 ampere, 110 volt rectifier.

Operation.—With fuses of proper capacity in place, close both the A. C. line switch and the machine table switch and bring the carbons together, whereupon the tube will rock, a spark appearing between the two mercury pools at each tilt until the arc starts, when the whole tube will light up and come to rest in a vertical position. The carbons should be instantly separated until the greatest amount of light is obtained on the screen.

Where the size of the theatre and equipment only justifies the purchase of a single rectifier, the problem of blending one reel into the next has been solved as described below: The only extra equipment necessary is a compensator or economy coil such as is usually found in a theatre using alternating current, and a four-pole, double throw switch.

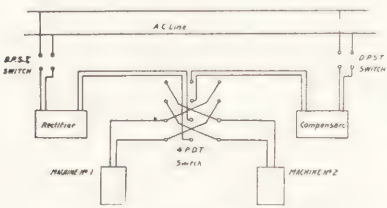


Plate 6, Figure 226.

The wiring is shown in Plate 6 and requires no elaborate explanation. By means of this plan the change-over may be made without any very seriously objectionable indication of the fact on the screen. The operator, we will say, is showing the first reel of a feature film on machine No. 1, which is fed from the rectifier, the switch being thrown to

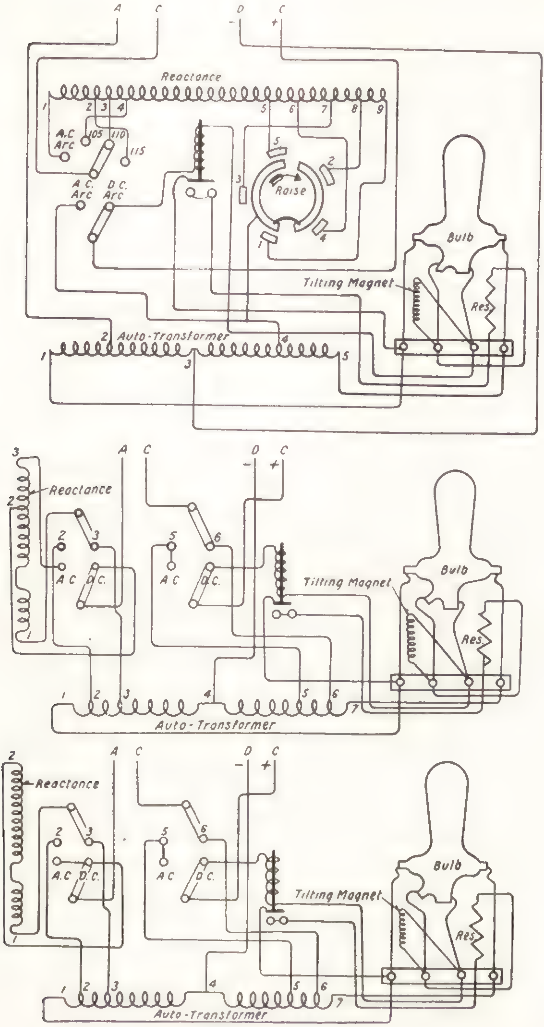


Plate 5, Figure 225.

the left. About one minute before the end of the reel is reached he throws the switch to the right, starting the arc on machine No. 2 through the rectifier, while machine No. 1 is transferred to the alternating current supply of the compensator, and the reel is completed in this manner. This gives the carbons on No. 2. time to burn to their proper brilliancy on D. C., ready to begin the second reel. The process is repeated toward the end of the second reel on machine No. 2. The procedure may, if desired, be reversed; that is to say, starting machine No. 2 on alternating current and later changing it to direct current. However, the first mentioned will be found more satisfactory, as it takes a short while for the direct current to burn the crater properly.

Always do it just as though the boss was around.

The Mechanism

General Instructions Applying to All Machines

MACHINES are very frequently sold to small town exhibitors who in the very nature of things are unable to employ competent operators, and who themselves have little or no knowledge of mechanics. When a part wears or breaks they are at a loss as to the method of procedure necessary to remove the same and replace it with a new one; also they are unable to make the necessary adjustments properly. *These men are doing a distinctly meritorious work in supplying theatrical amusement to what in the aggregate amounts to millions of people, who would otherwise be deprived of the pleasures of moving pictures. They are entitled to detailed information concerning these matters, and* ANY ADDITION TO THEIR KNOWLEDGE WHICH ENABLES THEM TO PUT ON A BETTER PICTURE IS ADDING TO THE PLEASURE OF ALL THESE MILLIONS OF PEOPLE WHO PATRONIZE SMALL TOWN OR VILLAGE MOVING PICTURE PLAYHOUSES.

Not only is this true, but, as a matter of fact, even competent experienced operators are sometimes at their wits end, and commit very serious blunders, simply because but few operators, except those in very large cities, are able to get experience on all the different moving picture mechanisms.

Some operators object to supplying detailed instructions on projector mechanisms. I think, however, to omit these instructions would be not only unfair to the industry as a whole, but also to the audiences who patronize moving picture theatres, and, moreover, to the operator himself. The claim that such instructions will have a tendency to create operators has, in my opinion, but little weight, and even if it did, the operator, important as is his function, is but one cog in the mechanism of the moving picture industry, and we must perforce look to the well-being of the industry as a whole.

There are certain general instructions which apply to all projection machines, as follows:

General Instruction No. 1. *Oil.* There is a tremendous amount of absolutely unnecessary damage done both to

projection machines and film, through lack of knowledge and care in the lubrication of projectors.

The much advertised patent oils are, I believe, without exception, absolutely unfitted for projection machine lubrication, and their use will, I am firmly convinced, shorten the life of a projector by fully one-third, if not more.

Too thin an oil is likely not only to have inferior lubricating properties, but also a decided tendency to run out the bearings and be thrown off by centrifugal force, all too often landing on the film or lens. Too thick an oil, on the other hand, is likely to be gummy, to collect dirt, and to remain in the bearings too long. One rule should, however, be rigidly adhered to by all operators.

NEVER, UNDER ANY CIRCUMSTANCES, USE MORE THAN ONE DROP OF OIL IN ANY MOVING PICTURE MACHINE BEARING.

Anything more is worse than useless, since one drop is ample for all purposes of lubrication, and the excess will simply run, or be thrown off, and make a dirty mess.

In my previous books I recommended a good grade of light dynamo oil for the projector bearings. I see no reason to change this recommendation. This oil can be procured, in bulk, from any oil dealer, and should cost not more than 25 cents a quart. The Projection Department of the *Moving Picture World* expended a good deal of energy and time in trying to locate a really good projector lubricant which could be bought at a reasonable price from film exchanges. The Latchaw oil was found, after exhaustive test, to be the only one to fill the bill, and it received the indorsement of the department. That however, was nearly two years ago, and while the oil was most excellent at that time I do not know what it is now, or even whether or not it is still on the market.

For the gears of the projector there are several very good lubricants, among them automobile cylinder oil, bicycle chain lubricant, automobile axle grease, and a good grade of vaseline. Beeswax also has been successfully used by some. A light lubricating oil is not suitable for gears. However, no matter what is used, if the machine is of the open type—that is to say, has no casing and the gears run in the open, there will be dust and dirt constantly collecting which, uniting with the oil, forms a grinding paste. It is, therefore, advisable to wash the gears of such machines thoroughly once or twice a week. This may easily be done, without removing the mechanism from the table, by placing a shallow dish or pan under the gears while you turn the crank slowly, at the

same time flooding the gears with kerosene from an ordinary squirt can such as is used to oil the machine. If preferred the mechanism may be taken off the table, immersed in gasoline and, first having removed the lenses and the crank, given a few turns while the mechanism is in the bath. This washes out both the gears and bearings very thoroughly. If the intermittent runs in an oil well, plug up the oil well oil hole before immersing the machine.

If the intermittent movement of your machine runs in an oil well a good grade of lubricant should be used therein. Some manufacturers recommend high grade vaseline for this purpose, which should be melted and poured in.

Personally the writter does not regard vaseline as a satisfactory lubricant. He believes that a good medium-bodied oil, such as a fairly heavy dynamo oil, is much better. But whatever you use in the oil well, *remember that the intermittent is subjected to exceedingly heavy service, therefore, unless the lubricant be high grade you may expect the cam pins to wear very rapidly.*

General Instruction No. 2.—Where the old style friction take-up is used it is of the utmost importance that the take-up tension be set just barely tight enough to take up the entire reel of film. Anything in addition to this is not only bad, but *very* bad. A minute's consideration will convince you of the importance of this matter. Throughout the entire process of rewinding the friction of the take-up will exert exactly the same amount of pull on the spindle which carries the take-up reel. When the film first begins to wind on the hub of the lower reel the take-up is pulling on the take-up spindle exactly as hard as it is when the process of rewinding is near its completion, but in the beginning the film is winding on the 1½ inch hub, whereas at the end it is winding on the outside diameter of a film roll ten or more inches in diameter. Therefore, since the take-up pull is constant on the spindle, *the actual pull exerted on the film at the beginning is very many times greater than it is at the end.* This means that the film is wound too tightly in the beginning and too loosely at the end, and that any unnecessary take-up tension only serves to aggravate the abnormally heavy pull at the beginning of the process of rewinding; moreover, it adds to the tendency to lose the lower loop in the earlier part of the run, besides the constant danger of pulling weak patches in two. Excessive tension is, in every way, deterimental, therefore be very careful and *don't set your take-up tension any tighter than is necessary to complete the process of rewinding.*

There have of late been some improved tension equalizers invented which equalize the take-up pull throughout the entire run. They should by all means promptly be adopted by machine manufacturers.

General Instruction No. 3.—It is of the utmost importance that the sprockets of your machine be kept perfectly clean. This is particularly true of the intermittent sprocket. The best method of cleaning them is as follows: Procure an ordinary cheap toothbrush and a wide-mouthed bottle or a small tin can with a cover. If a bottle is used punch a hole in the cork and fasten the tooth brush therein in such position that it will reach the bottom of the bottle when the cork is in. If a can be used do the same thing with the lid. Now fill your bottle or can with kerosene, and just as soon as the least bit of gum or dirt begins to gather on the face of the intermittent sprocket scrub it off with the toothbrush wet with kerosene. Go over your sprockets carefully once every day and be sure they are perfectly clean. Dirt on the upper or lower sprocket will have a decided tendency to cause the losing of the loops.

Dirt on the intermittent sprocket will make the picture jump on the screen, not sometimes but always.

It is an astonishing fact that many operators do not seem to grasp this simple and seemingly self-evident idea. I have actually known of a projection mechanism being shipped to the factory from a distance of two thousand miles, with a complaint that the "picture jumped terribly." On examination the face of the intermittent sprocket was found to be covered with gum and dirt. This was washed off, the machine tried out and the picture found to be as steady as a rock. Imagine, if you can, sending a machine more than two thousand miles merely to have the face of the intermittent sprocket cleaned off; a thing the operator could have done in less than two minutes, by the aid of a little kerosene and a ten-cent toothbrush.

General Instruction No. 4.—It is important that the sprockets of your machines be kept in perfect line with each other and with the aperture. I cannot give definite instructions as to how to test the lining of the sprockets, since this will vary with each different make of machine. The meaning is set forth in Fig. 227, in which the dotted line is presumed to be exactly central sidewise in the aperture and perpendicular thereto. The upper, lower and intermittent sprockets must be exactly central sidewise with this line, or, in other words, the teeth on each side of each sprocket must be equidistant from the line. This may be

roughly tested, so far as the intermittent and upper sprocket be concerned, as follows: Using a piece of new film, of some make that is known to have perfect perforations, thread a short piece, say one foot long, into the machine, engaging it with the teeth of the upper and intermittent sprockets, and closing the idlers. Turn the fly-wheel *backward* until the film is stretched tightly, being careful that the sprocket teeth are in the center, sidewise, of the sprocket holes. If the upper and lower sprocket and the aperture are not in line the fact will be detected by the film-edge not being in line with the tracks on the aperture plate, or the aperture plate not being central in the film. If the film seems to bear equally on both edges of both sprockets and the aperture plate tracks are not straight with the film, it would indicate the probability that the aperture plate itself is out of true. In some machines this may be easily remedied; in others the aperture plate cannot possibly be out of true and the indication would be that both the upper and intermittent sprocket is too far over to the right or left. Before making this test, however, it is essential that you be sure your intermittent sprocket shaft is in exact alignment with the cam shaft.

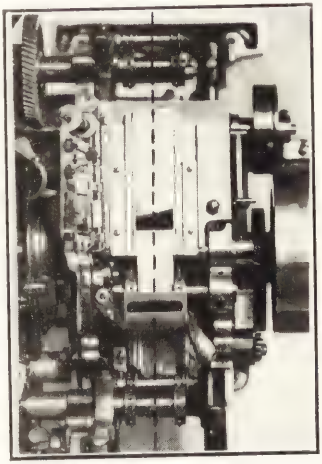


Figure 227.

General Instruction No. 5.—The intermittent movement, that is to say, the star and cam, or in the case of the Power Six the cam and cross, must be set up closely enough that there is very little circumferential play in the intermittent sprocket. This must not, however, be carried to excess. It is not wise to attempt to eliminate all circumferential play in the intermittent sprocket when the machine is cold. If you do, when the machine becomes warm the expansion of the parts through heat will set up undue friction, and cause excessive and unnecessary wear. It is a mistake to suppose that a little circumferential play in the intermittent sprocket will cause unsteadiness in the picture. It does no harm whatever, though it does not follow that an *excess* of movement would

not be harmful. Set it just so that you can barely detect some movement when you try to rock the sprocket with your finger. Don't try to adjust the intermittent as above if the cam or intermittent shaft bushings are worn. Where a machine is of a type to allow of its being done I would strongly advise managers and operators to *have a complete framing carriage on hand all ready to slip into the machine.*

The replacement of the intermittent sprocket, star, cam, or their shaft is a very delicate operation, and one which really *should be done at the factory.* If you have an extra framing carriage, with all the parts assembled, when the parts become worn, you can take the old carriage out, put in the new one, and send the old one to the factory, by parcel post, where it will be repaired in the best possible manner. This latter does not apply to Standard or Edison.

General Instruction No. 6.—The top idler on the gate or whatever takes its place is for the purpose of holding the film central over the aperture, guiding the film down into the gate, and helping to eliminate side motion. It should be kept so set that it holds the film snugly, but without binding, and so set that the film will be exactly central over the aperture. In some machines the position of this guide is fixed and cannot be altered; in others it may be altered, and if set loosely enough to allow the film to have free side play there is likely to be side motion of the picture on the screen. Also if it be set over too far there is a possibility of the sprocket holes showing on one side of the screen.

General Instruction No. 7.—*There must be no end play whatever in the intermittent sprocket.* End play in the intermittent sprocket is likely to produce side motion in the picture on the screen. It does not necessarily follow that the picture will have a side motion because there is end play in the intermittent sprocket, but it is highly probable it will, nevertheless.

General Instruction No. 8.—It is a serious mistake to use an intermittent sprocket after the teeth have become appreciably worn. The wise manager or operator will not attempt to save money by using an intermittent sprocket with worn teeth, since the using of such a sprocket is bad from any and every point of view. Worn intermittent sprocket teeth are very hard on the perforations of the film and very apt to produce unsteadiness of the picture on the screen. Worn teeth also have a decided tendency to cause the teeth to climb the sprocket holes, thus losing the lower loop. The intermittent sprocket teeth do all the work of

pulling down the film against the friction of the tension shoes, hence are subject to heavy wear. The operator should examine his intermittent sprocket teeth, using a condensing lens as a magnifying glass, every few days. As soon as there is evidence of appreciable wear the sprocket should be promptly renewed. The same thing is true in lesser degree of the upper and lower sprockets, though moderate wear on the teeth of these is not so harmful; moreover, these sprockets may in some and I believe in all makes of projectors, except the motiograph, be removed and turned end for end, thus presenting an entirely new tooth-surface to the film when one side of the teeth has become worn. The same thing is accomplished with some makes of machines by substituting the lower sprocket for the upper sprocket, and vice versa.

General Instruction No. 9.—It is highly important that the tension springs of your machine be kept adjusted exactly right. The short piece of film between the upper and lower loop is to all intents and purposes temporarily detached from the rest of the film. That is the object of and reason for the upper and lower loops. They allow of the strip of film between them being started and stopped intermittently, while the rest of the film runs continuously. When the intermittent sprocket acts it jerks this little strip of film down three-quarters of an inch, thus temporarily lengthening the lower loop by three-quarters of an inch and shortening the upper by just that much. The office of the tension springs is to stop this strip of film when the intermittent sprocket stops and hold it perfectly still and perfectly flat over the aperture during the time the photograph is being projected to the screen. Bearing this fact in mind, it will be seen that if the tension springs be too slack they will not stop the film (it moves at high speed while the intermittent is in motion) exactly when the intermittent sprocket stops. In other words, the film will "overshoot," and, inasmuch as it will probably not overshoot exactly the same amount every time, unsteadiness of the picture on the screen will result. On the other hand it readily will be seen that, while it is absolutely essential that the tension springs be tight enough to stop the film when the intermittent stops, and thus prevent overshooting, still, any tension in excess of this will make the work of the intermittent sprocket teeth, of the intermittent movement, and, in fact the whole mechanism, just that much harder, with the result that there will be unnecessary wear on the whole mechanism and the

film itself. It is a difficult matter and an impossibility to adjust the tension so that it will be always exactly right, since one piece of film may be a trifle thicker than another, or a little bit smoother, or more oily. The operator, however, should be very careful and come as close to the proper adjustment as he possibly can.

The tension may be considered as being approximately correct when the picture is steady and without movement on the screen when run at any speed up to 90 per minute, but at 90 or thereabouts the picture begins to crawl up slightly on the screen.

Another fairly accurate test is to set the tension so that you can just barely feel the pull of the intermittent movement when the crank of the mechanism is turned very, very slowly, and by "very, very slowly" I mean exactly what I say—just barely moving. If you can feel the jerk of the tension appreciably when moving the crank thus, then the tension is too tight. It is a fact, however, that it is not always necessary to have the tension tight enough so that you can feel it in the crank, even when moved as slowly as you can move it. The 90-foot-per-minute-test is, everything considered, the best I know of.

General Instruction No. 10.—When running first run films, the emulsion of which is soft, there is a decided tendency of the emulsion to deposit on the tension springs or on the shoes. This tendency is often helped out by the too liberal use of cement in making patches. The emulsion and the cement gather on the polished surface of the tension shoe in a hard, unyielding mass, which, aside from making the

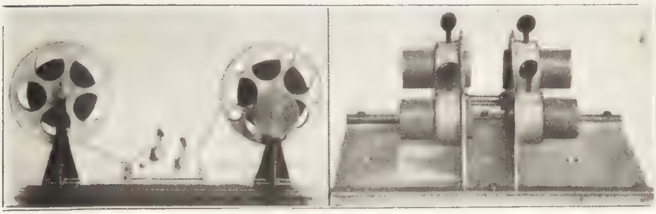


Figure 228.

tension shoes jump and clatter is very apt to injure the film, and perhaps injure it seriously too. Sometimes the excess cement on the celluloid side will gather on the aperture plate tracks also. When running first run film the tension springs and aperture plate should be carefully examined after each

reel, and any deposit found thereon should be carefully cleaned off by using a wet cloth (water softens the emulsion instantly) or the edge of a silver coin, or some other soft metal.

Never use a knife blade, a screw driver or other hard steel instrument to scrape off the aperture tracks or tension shoes; by so doing you will be very likely to scratch the polished surface, thus increasing the tendency to deposit and aggravating the trouble.

The deposit of emulsion may be very largely stopped by the use of the machine illustrated in Fig. 228. The illustration is, I think, fully self-explanatory. The machine is placed between reels on the rewinder, and the film runs through it in rewinding. The four round objects are cylinders made of wax, so set that in the process of rewinding the tracks of the film bear on the wax and receive a sufficient deposit of it on both sides to prevent the deposit of emulsion or cement on the tension shoes or aperture plate of the projector. The same thing may be accomplished by a home-made affair, using large sperm or tallow candles, as per Fig. 229, but the machine in question is cheap in price and quite efficient, therefore I can advise its purchase. The mere rubbing of the tension springs with the butt end of a tallow candle when threading the machine helps considerably,

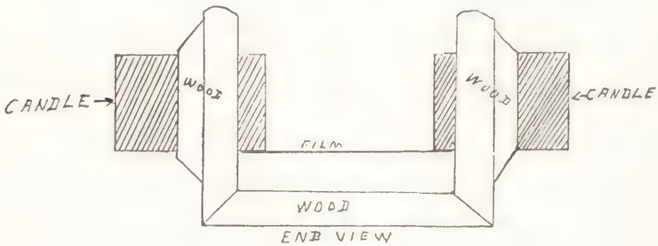


Figure 229.

though it will not prevent deposit. Another method which is fairly efficient is to hold a tallow candle lightly against the teeth of the upper sprocket every half minute or so when running first run films. This scrapes off a little tallow which deposits on the tracks sufficiently to keep the tension springs or shoes lubricated.

General Instruction No. 11. It is important that the tracks of the aperture plate of your projector be not allowed to

become much worn. It is absolutely essential to good results on the screen that the film be held absolutely flat over the aperture during the time the picture is being projected, and this is not likely to be done if (a) the aperture plate tracks be appreciably worn; (b) the shoes or springs do not set squarely on the tracks, but one or both of them is over to one side. Worn aperture plate tracks are likely to produce a buckling of the film, with consequent in and out of focus effect in the center of the picture. This is particularly true of the type of mechanism which employs a limber tension spring, instead of a stiff tension shoe. By this I do not wish to be understood as saying that in and out of focus effect is always due to the above causes. It may also be due to an old, dry, shrunken film, or to too much pressure by the tension springs.

General Instruction No. 12.—It is of the utmost importance that the sprocket idlers be kept in line with the sprocket, so that each side of the idler is equidistant from the face of the sprocket, and that the distance of the idler from the face of the sprocket be two thicknesses of a film or a trifle less. If the sprocket idlers be not so set there is likely to be trouble, particularly at the lower sprocket. Losing the lower loop through the film climbing the sprocket teeth is very often directly due to the improper setting of the idler. It is either out of line with the sprocket or too close to or too far away from the sprocket. *Many do not realize the importance of a close adjustment of their sprocket idlers.* Never allow your sprocket idler to "ride the film"—that is to say, to bear on it with pressure. This is especially bad if the pressure is greater on one side than on the other, and will most likely cause the film to climb the sprocket at the first bad patch. This does not apply to the Edison machines. Their idler rollers ride directly on the film, which is held in place by deep flanges at either end of all sprockets. See to it that your sprocket idlers turn; if they do not they will soon develop a flat spot, and sooner or later this means trouble.

General Instruction No. 13.—It is highly important that the intermittent sprocket shaft and the cam or fly-wheel shaft be kept in exact alignment with each other. The position of the cam or fly-wheel shaft is fixed and cannot be changed. It will readily be seen that if the intermittent sprocket shaft be out of line with the cam or fly-wheel shaft—that is to say, if one end of the intermittent sprocket shaft be high or low with relation to the other end—it will bring one end of the intermittent sprocket lower than the other end, and the

teeth at the lower end will be obliged to do all the work of pulling down the film until such time as they have worn off sufficiently to bring the teeth on the other end into play, whereupon, if the shaft then be lined, the opposite condition will obtain, and the teeth on the other end will be doing all the work. This would be very hard on both the film and the sprocket. The method of aligning these two shafts will vary with different machines, and must be left largely to the judgment and ingenuity of the operator. In all machines in which the intermittent sprocket shaft has a bearing at either end the adjustment is made by means of two eccentric bushings, and there is always the liability, when making an adjustment for the purpose of eliminating lost motion in the intermittent, to turn one bushing more than the other, thus getting the sprocket and shaft out of level with the cam shaft. In some machines the distance between the two shafts at either end may be tested with a caliper. With other machines, however, this test is of no value, since the diameter of one or both the shafts is smaller at one end than the other. The competent operator, however, will certainly be able to devise some effective method of testing this matter, and he should by all means do so, since it is of the greatest importance.

General Instruction No. 14.—On the old type machines it is very important indeed that the magazines be accurately lined with the machine. With the newer projectors this is taken care of at the factory, and the magazines can only be placed in one position, therefore cannot possibly be out of line. The film in passing out of the upper magazine and into the lower magazine must travel through the fire trap, and if the magazine is out of line with the machine the film is likely to rub against the side of the trap and in time cut the metal in two, thus ruining the fire trap; also if the upper magazine of the old style machine is much out of line it is also quite possible the film will not come down squarely to the upper sprocket, and this is likely to make trouble. If it be the lower magazine that is much out of line then the take-up will pull the film sidewise and there will be added tendency to lose the lower loop. The film should pass from the upper and into the lower magazine without touching either side of the trap.

General Instruction No. 15.—It is a most excellent scheme to have operating room reels and only use the exchange reels, which are very apt to be in more or less bad condition, in the upper magazine for the first run, placing one of the

house reels in the lower magazine to receive the film. The film should thereafter be handled on the house reels entirely, being rewound to the exchange reel only when using for the last time. These house reels should be kept in first class condition, with the spring clip carefully adjusted. Better still, make a slot through the wooden hub and dispense with the spring clip entirely. It is aggravating for the operator who has to do rapid work in threading up to be obliged to work with a reel which is in bad condition. The only way to avoid this with any degree of certainty is by a theatre owning reels of its own. There is a most excellent reel spring made by Chas. F. Woods, Princeton, Ind., known as the "Woods Improved Film Clip," with which operators will do well to equip their house reels. The construction and operation of this little device is clearly shown in Fig. 230.

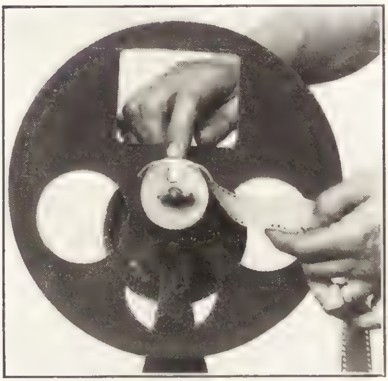


Figure 230.

General Instruction No. 16.—In most projection machines there is some sort of tension device in the upper magazine, designed to prevent the reel from revolving too freely, and it is important that (a) this tension device be so designed that it will not and cannot catch on loose screws on reel hubs; (b) that the tension be sufficient to just barely keep the film taut at all times, and stop the reels instantly when the projector is stopped. The importance of this is seen when we consider that, if the reel revolves too freely, and the machine be stopped when the upper reel is three-fourths or more empty, and the reel continues to revolve, thus unwinding more or less slack film, when the machine is started it is likely to get up to normal speed before it takes up all the slack, and then the reel must be started instantly at full speed. As a result there is a heavy jerk, which may pull patches in two, rip out sprocket holes, or even pull the film itself in two.

General Instruction No. 17.—It is sometimes desirable that

the form of the aperture be changed in order to eliminate the keystone effect due to a steep pitch in the projection or the keystone effect due to a side throw. This may be accomplished by taking off the aperture plate, filling in the same with solder for one-sixteenth or one-eighth of an inch at either side, or if it be a side keystone effect, then at the top and bottom. Having completed this part of the job, put the aperture back in place, and, with the light projected to the screen, using a small, fine, flat file, carefully file the sides until the light on the screen is perpendicular on the sides or horizontal on top and bottom if it be keystone effect. Do your filing slowly and carefully. It is well to hang lines at the sides of the screen to guide you in your work. Attach top of line (narrow, black tape is good) to screen, just at bottom of top corner bend and attach weight to its lower end so it will hang perfectly straight and perpendicular.

THE REVOLVING SHUTTER

General Instruction No. 18.—It is of the utmost importance that the operator have a comprehensive and complete knowledge of the principles involved in and the optical action of the revolving shutter. The revolving shutter of a projection machine serves a certain definite purpose, viz:

It shuts off the light from the screen during the time each individual picture is being moved down to make room for the next, and turns it on again while the picture is being projected to the screen.

Remember there is really no such thing as a "moving picture." What we term "moving pictures" are in reality a blending or dissolving of snapshot photographs, taken at the rate of about sixteen to the second, into each other at approximately the same rate of speed at which they were taken.

Examine your film; measure off one foot of it and you will find thereon precisely sixteen complete pictures, which are nothing more or less than snapshot photographs taken at the rate of approximately sixteen to the second. These photographs are strung out, one after the other, on strips of celluloid of varying length, several lengths being joined together into a total length of one thousand feet, which is the ordinary length of a "reel of film." As the film passes through the projector these photographs are successively displayed, in an inverted position (upside down), in front of the machine aperture, and are projected, one after the other, to the

screen. In order to accomplish this the photographs must each one be standing perfectly still, and lie perfectly flat over the aperture during the period of projection. The intermittent movement of the machine is for the purpose of pulling each successive photograph away from over the machine aperture and replacing it with the next succeeding picture, or, in other words, moving the film down exactly three-fourths of an inch, stopping it dead still while the picture is being projected to the screen, and then jerking it down again, and so on throughout the full length of the reel of film. As a matter of fact, at ordinary speed, each picture occupies one-sixteenth of a second from the time it begins to move until the next picture begins to move, about one-sixth of this time being consumed in the actual movement of the film and five-sixths in the projection of the picture. And right here the office of the revolving shutter comes in. If you have an outside shutter machine, slip the shutter off its spindle and project a few feet of film. You will find that the picture will be projected, and that the light will be far more brilliant than it was with the shutter in place. You will find, however, that from every white object in the film there will be a streak of white, which apparently goes both up and down from the object, but in reality goes down only, the other end being the effect of a similar white object in the next picture. The net result is streaks of white across the picture. This is what is called "travel ghost." It is due to the fact that as the picture is jerked down, to make way for the next one, the effect of impression of any white object therein on the retina of the eye is greater than the effect of impression of the surrounding dark objects in the film. Hence as the picture is moved down we see white moving across the space formerly occupied by the darker object in the picture. In other words, the eye follows the white object as it moves across the aperture, but it does not see the dark object, or at least does not see it so plainly. Owing to this effect it is necessary to shut off the light from the screen during the time the film is in motion, and *that is the duty the revolving shutter performs.*

Without any film in your machine, open the gate, project the white light to the screen, and run the projector very slowly. You will observe that the revolving shutter shuts off *all* the light from the screen every time one of its blades comes in front of the lens; hence two or three (according to whether your machine has a two or three wing shutter) times during the period a picture is being exposed and projected the light is

entirely cut off from the screen. In actual projection we therefore have, in effect, a succession of flashes of brilliant light and total darkness, but when the machine is run at normal speed, with a properly designed shutter, these flashes of light and darkness alternate so rapidly that either the eye does not catch the effect at all or catches it but slightly. So far as our eye is concerned the illumination of the screen is continuous, though of diminished brilliancy.

No matter how many blades your shutter may have, only one, the wide or main blade, has anything whatever to do with the actual shutting off of the light during the time the picture is being moved down to make way for the next. As the intermittent sprocket starts to move the wide blade of the shutter comes in front of the lens (that is what is meant by "timing the shutter"—setting it in such relation to the intermittent movement that it will cut off the light from the screen as the intermittent begins to move, and turn it on again just as the movement ceases) and shuts off the light from the screen while the intermittent sprocket is moving and pulling the next picture down over the aperture. As the intermittent sprocket comes to rest the wide blade of the shutter passes from in front of the lens, thus allowing the picture to be projected to the screen.

From this it is seen that, in theory, the shutter must be so set that it will cover the aperture, or lens, at the exact instant the intermittent begins to move, and uncover it at the exact instant the intermittent sprocket comes to rest. That is the theory. In practice, however, it has been found that this may be modified to some extent, and, as a matter of fact, with most machines, the lens is only about three-fourths closed when the intermittent sprocket begins to move, and is still slightly open when the movement ceases. If, however, the leeway be just a little bit too much there will be travel ghost.

All this has to do with the wide blade of the shutter. All shutters, however, have two or three wings, but these extra wings have nothing whatever to do with cutting off the light during the time the film is moving. But while this is true they are, nevertheless, of the utmost importance. As already has been explained, in projection the screen is alternately brilliantly lighted and totally dark. Now the human eye is a peculiar instrument. It will transmit to the brain a certain number of separate impressions per second, as separate impressions, but beyond that number the impressions become merged into each other so that the effect is that of con-

tinuity. This is what is called "persistence of vision," and it is this peculiarity of the eye which makes "moving pictures" possible. So far as the shutter be concerned, persistence of vision acts as follows: If the flashes of light and darkness come too far apart, or are disproportionate to one another, then the eye will perceive the difference. Under this condition persistence of vision operates incompletely, and instead of an illusion of perfectly steady illumination the rapidly recurring flashes of darkness will be perceptible in the shape of what is termed "flicker." This flicker is a very serious matter indeed, since it causes eye strain exactly in proportion to its amount. If excessive it is highly injurious to the eyes. It has been found that if the flashes of light and darkness be equal to each other and at the rate of forty-eight or more of each to the second, the effect will be, to all intents and purposes, that of continuous illumination, without any perceptible flicker at all, when not very brilliant illumination is used. With more brilliant illumination, such as is now used in up-to-date theatres, this must be increased to about 55. Therefore this is the condition machine manufacturers are striving to attain, or should strive to attain. But in order to attain this there must be a three-wing shutter, with all three blades of the same width, and three light openings each of equal width with the blades.

This might seem to the uninitiated a simple condition to accomplish, but, as a matter of fact, it is not. It brings up some very difficult problems. First,· as has already been pointed out, the main blade of the shutter *must* be wide enough to cover about three-fourths of the aperture, or light beam, when the intermittent sprocket starts to move and still have about the same amount covered when it comes to rest. This fixes the minimum width of the main blades arbitrarily. It also means that

The more rapid the intermittent movement, the less width the main shutter blade need have,

and with a 1 to 6 movement, provided there be no lost motion between the revolving shutter and the intermittent, a condition is approached where the outside shutter may have three wings, each wing of equal width with the other wings and he light openings. This is, I believe, the best condition obtainable, and I am of the opinion that it will be the best so long as intermittent projection machines are used.

It is, however, not always possible to attain this condition, since it presumes the light ray to be cut at the narrowest possible point, and with very short focal length lenses the

light ray spreads so rapidly that with lenses and projection machines as at present made the shutter can only cut the beam after it has spread too much to allow of the ideal condition, before described, being attained. With very short focal length lenses the beam is so wide that the main shutter blade must have abnormal width in order to eliminate travel ghost, and this throws the shutter out of proportion and makes for flicker when the machine is run at normal speed.

Where 60 cycle A. C. is used, however, the use of the three-wing shutter brings in another equation, 60 cycle A. C. reverses its direction 120 times per second, or 7200 times per minute. With a three-wing shutter projection machine running at the rate of 60 feet of film per minute, normal speed, the light is cut 2880 times a minute. Now one-half of the alternations of 60 cycle A. C. would be 3600, and if the current happened to be not quite 60, but, say, instead, 56 or 58, just a little of overspeeding of the machine would bring the wings of the shutter into synchronism with one side of the alternations. Under these conditions if the wings happen to cut the light just at the period of its greatest brilliancy (See Page 16, Fig. 4) its power would be diminished by approximately one-half. As a matter of fact, however, this very thing often does occur where a three-wing shutter is used with 60 cycle A. C., and the net result is a waving effect of the light; that is to say, its brightness will alternately diminish and increase, the alternations of effect being due to the fact that the shutter blades are not likely to stay in exact synchronism with the alternations for more than one or two seconds at a time. For this reason it is advised that a two-wing shutter be used with 60 cycle alternating current. The two-wing shutter, as a rule, gives somewhat more light than the three-wing shutter, and is therefore favored by some managers who prefer to have flicker rather than current bills. The use of the two-wing shutter, however, is not to be advised except with 60 cycle A. C., or with gas or other weak illuminant.

In this connection let me say that the tendency to flicker increases with the brilliancy of the projection and with increase of size of picture, and conversely diminishes with decreased brilliancy of projection and decrease in size of picture.

All this has been explained at considerable length in order to give the operator as clear an understanding as may be had of the points involved, but in addition to the foregoing there is still another exceedingly important point which should receive due consideration.

Almost all the later models of projectors are equipped with an "outside shutter." Where the outside shutter is used another point of much importance is involved, viz: width of the light beam at the point the shutter cuts it, or, in other words, the position of the shutter as regards its distance from the lens.

In Fig. 63A, Page 145, the method of determining proper location for the shutter is shown. Place a piece of metal with a hole, say, one-quarter inch in diameter against the condenser so that the hole will come approximately in the center of the condensing lens. Now open machine gate, project the light through this hole to the screen. Blow a little smoke on a ray just in front of the lens and you will find the ray to appear as in Fig. 63A, though the thinnest point may be inside the lens barrel if the lens be of short focal length. The correct position for your shutter is at the thin point of the ray, provided you can get it there, but this does not apply to either very short focal length lenses or very long focal length lenses. In fact, it only applies to lenses between, say, 3½ and 4 inches, and about 5½ and 6 inches e. f. When the lens is in the right position the correct position for the shutter may also be determined by watching it cut off the light on the screen when revolved very slowly. *If the shadow is moving in a contrary direction to the movement of the shutter, the shutter should be moved toward the screen; if the shadow moves in the same direction as the shutter the shutter is too far from the lens.* When it is in correct position the effect on the screen is a dissolving effect, the shadow entering the screen both from above and below. When the shutter is in correct position the periods of absolute darkness may be considerably shorter than the periods of absolute brightness when using a 50 per cent. two-blade shutter. Therefore, there is actually a gain in light by having the shutter in the right position, and this gain is equal to twice the diameter of the light beam, there being four edges on a two blade shutter, and as the light decreases or increases while being cut from full to zero the gain on each edge is equal to one-half of the diameter of the beam, the result of the comparatively gradual change from light to darkness should result in a softer tone and diminution of flicker effect.

The width of the shutter blade may be tested by observing whether or not any part of the bright spot of light leaves the shutter during the movement of the intermittent sprocket. If it does this on one side then the shutter is not set right;

if it does it on both sides the shutter blade is too narrow and there will be a tendency to travel ghost. If, when the intermittent sprocket stops, the edge of the bright spot has not reached the edge of the shutter, then the main blade is unnecessarily wide and there is light loss. The intelligent application of this method will show at a glance exactly wherein the main shutter blade lacks in being adapted to local conditions.

The reason why an outside shutter of large diameter can be better proportioned than can an inside shutter of small diameter is illustrated at Fig. 231, which will convey an accurate idea of the effective difference in shutters of small diameter and others of larger diameter. In the sketch "X," the aperture opening, is eleven-sixteenths by fifteen-sixteenths of an inch. With the small, inside shutter illustrated by the smaller circle c b a, the lines a b indicate the width of shutter blade necessary to cover opening X, without providing for its being covered during the time the film is in motion. Lines a c indicate the additional width of shutter blade necessary to provide for covering opening X during the travel of the film.

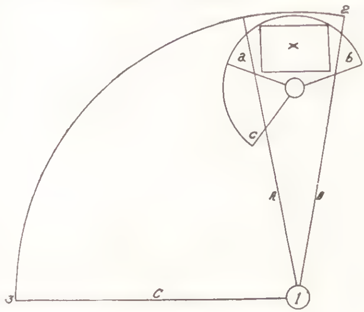


Figure 231.

You will thus see that with a shutter of small diameter a blade of great width, as compared to the total circle, is essential if opening X is to be covered during the entire time the film is in motion. This is primarily because of the excessive width of blade required to cover the aperture in the first place.

It is not difficult to see that, under these conditions, it would be impossible to add more than one other blade to such a shutter, and even that blade could not be of very substantial width unless a very large percentage of the total light be cut. In practice, however, the inside shutter is not, of course, of such extremely small diameter as shown, but it is nevertheless too small to admit of using three blades of anything like equal width, as is necessary if three are to be used and the flicker reduced to a minimum.

On the other hand, take a shutter of the outside type, having a radius as indicated by 1-2 and 1-3 (radius means one-half the diameter of a circle), and it will be observed that lines A B form a blade covering aperture X, whereas lines B C form a blade capable of covering opening X during the entire movement of the film. You will observe, too, that this blade, instead of occupying more than half the circle, actually covers but a trifle more than one-sixth of it. We will thus be enabled to add two more blades of substantial width, and still cut no more light than would the smaller shutter having but one or two blades.

Fig. 231 contains the meat of the whole shutter matter as applied to the relative merits of inside and outside shutters. It all sums up in the fact that a shutter of very much larger diameter may be used outside, thus allowing of a better arrangement of "flicker blades." Added circumferential or peripheral speed also helps a little.

General Instruction No. 19.—A strongly magnetized screwdriver is an excellent operating room tool. Small machine screws may then be removed or inserted without danger of dropping them, with resultant vexation and trouble.

General Instruction No. 20.—The standard aperture now in use is .6796 inch high by .9062 inch wide.

INSTRUCTIONS FOR VARIOUS MECHANISMS

The instructions for the various mechanisms are intended to enable the operator to perform any operation which may at any time be necessary. By means of the photographs and system of numbering the parts, it is hoped and believed that the method of removing and replacing or adjusting various parts of the machine will be made so plain and simple that even the inexperienced man will have little trouble in understanding and following the instructions, whereas the experienced operator will be greatly aided when called upon to take charge of a mechanism which is new to him.

At first glance the various instructions may seem somewhat complicated. They are, in fact, very simple and easily followed. In this connection it must be remembered that the operator seldom has occasion to use more than one of the instructions at a time, while some of them will be used very rarely and perhaps not at all.

The numbers refer to parts and plates, thus: 678, P. 7, means that part 678 will be found on Plate 7; 682, P. 3 and 5, means that part 682 will be found on both Plates 3 and 5.

Instructions for the leading makes of machines will be

found on the following pages: Edison Super-Kinetoscope, 477; Power's Cameragraph, 491; The Simplex, 513; The Motiograph, 528; The Standard, 5[illegible]; The Baird, 546, and the Edison Model D, 579.

Edison Super-Kinetoscope

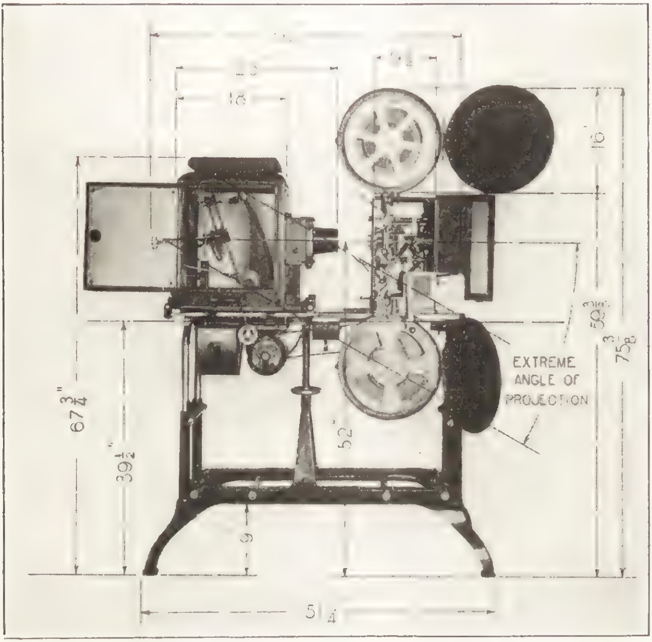


Figure 232.

Important Notice.—The Super-Kinetoscope table rods only allow about 18 inches from apex of front condenser lens to film. Where this will not allow the matching of lens system as in table 1, Page 141, the Edison company will, without charge, exchange these rods for special longer ones.

IN the following instructions only directions for disassembling the various parts of the mechanism are given, it being intended that the operator carefully study the situation before he starts taking the parts off and that he closely watch the disassembling and reassemble by reversing that process.

No. 1.—To remove the casing from the Super-Kinetoscope, first open both doors and at the top hinge corner will be found a stop. Release the stops on both doors by taking out the screw which fastens them to the door casing. Next remove screws 26245 (four of them) P. 1, and take off the revolving shutter casting, then remove nine round head screws in the front plate (lens end), which will release the entire front plate and the two doors. You may then take off the back plate by releasing the set screw in knob 26205, P. 1, and removing three round head screws at the top and three at the bottom. In replacing the mechanism on its base, first, before you set it down on the base, pull the automatic stop 26131, P. 3, back so that it stands straight up, also guide vertical shaft so that the screwdriver-shaped end enters take-up friction disc slot. If you don't do this the contact pin which sets down in a slot in the casting is likely to strike and become injured. There are two dowel pins in the base. Set down the mechanism so that it enters the pins.

No. 2.—The mechanism is released from base casting 26290, P. 4, by removing hexagon head screws (three of them) 26019.

No. 3.—Balance wheel 26184, P. 4, may be removed as follows: With a large screwdriver remove screw 26186, P. 4. In the face of the wheel hub will be seen a slot. Set this slot straight up and down and with the point of the screwdriver tap sharply on the top edge of what appears to be an offset in the casting of the wheel but what is really a key washer. A sharp blow will displace this washer, whereupon, holding gear wheel 26277, P. 4, stationary, pull the balance wheel off the spindle with a twisting motion. The reassembling is but a reversal of the foregoing process, but be sure to get the key washer properly located in its slot.

No. 4.—To remove gear 26277, P. 4, follow Instruction No. 3 and remove hexagon nut 20622, P. 3, and tap lightly on the end of the bolt, the head of which is shown at 26042, P. 4. Having removed the bolt, the gear may be taken away, carrying with it pinion 26277, P. 2. This pinion may be removed from the large gear and replaced, but the job can only be done at the Edison factory. Don't try to have your local machinist do it unless you are looking for trouble.

No. 5.—To remove gear 26031, P. 4, follow instructions Nos. 3 and 4 and, holding the gear stationary with a large screwdriver, remove screw 26033, P. 4, and, using a hard wood or copper punch, drive the shaft out. In the end of the shaft will be found a key. Be careful and don't lose it; also don't

fail to get it back in place in the assembly. This shaft is the main driving or crank shaft.

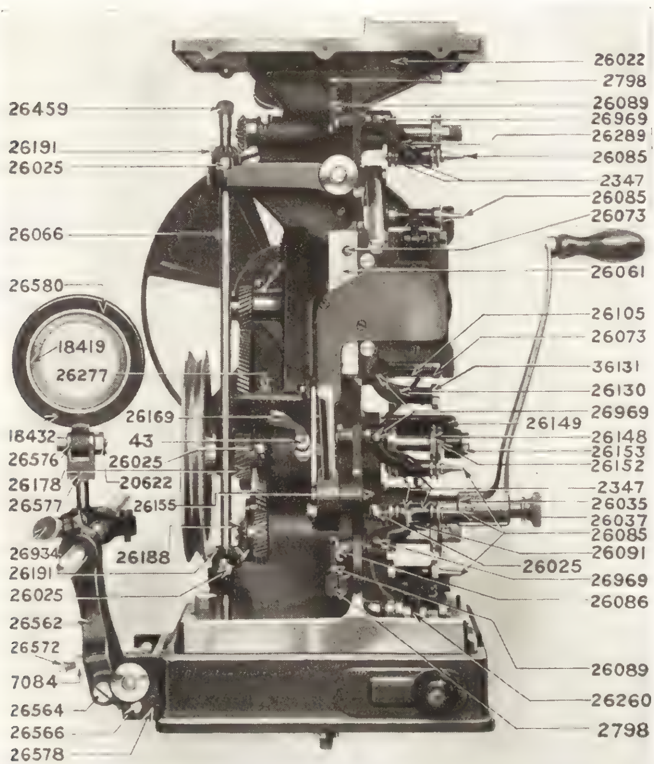


Plate 1, Figure 233.

No. 6.—The main crankshaft to which crank 26690, P. 3, is attached is removed by following Instruction No. 5.

No. 7.—Gear 26045, P. 4, is held to its shaft by a set screw in its hub and is located circumferentially on its shaft by a key. To remove the gear loosen the set screw and pull the gear off, being careful not to lose the key and to get it properly located in reassembling.

No. 8.—Gear 26191, P. 3, is held to its shaft by a set screw in its hub which bears on a key bending into a key way in its shaft and gear. The gear may be removed by releasing this set screw and pulling outward on gear 26045, P. 4, tapping, if necessary on the inner end of the shaft with a small copper or hard wood punch.

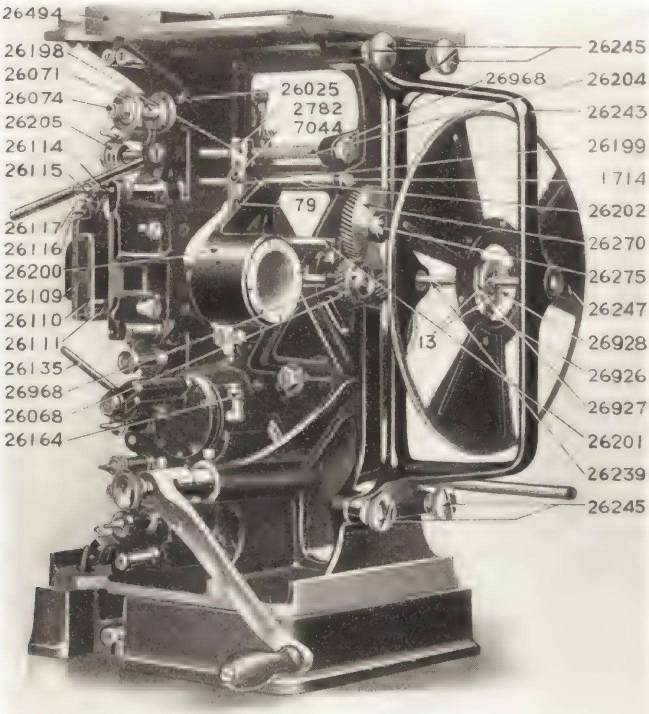


Plate 2, Figure 234.

No. 9.—To remove lens carrier 26194, P. 3, loosen set screw 1714 and another one similarly located at the other end of the shaft and two similar set screws in the casting at the end of shaft 26201, P. 1, which supports the casting. Next remove gear 26270, P. 1, by loosening set screw in the cast-

ing opposite the inner end of its spindle and pulling the gear out. You may then, using a hard wood or copper punch, drive rods 26202 and 26201 inward, toward the operating end of the machine (until casting 26194, P. 3, is released). The reassembling is but a reversal of the process of disassembling, but in working with parts of this kind remember they are fitted closely and if they move a little bit hard don't go at things with a ten-pound hammer, but have a little patience and keep tapping until the part is released.

No. 10.—To remove shaft 26069, loosen screws (two of them) 26966, P. 4, in the collar next to the governor and one screw in the hub of the governor. Next loosen pin screw 26049 in the hub of gear 26067, P. 3, and then, holding the governor and its collar stationary, pull the shaft out. It may be found that the gears and collar of this shaft will stick somewhat and you will have to use a little force in starting the shaft out.

No. 11.—To remove the automatic governor and fire shutter 26207, P. 3, loosen screw in the hub of governor. Next remove screw 26073 and another similar screw in the lower end of part 26061, P. 2, which releases the entire governor and plate which may be pulled straight out off the shaft. It is not deemed expedient to disassemble the automatic governor itself. It is exceedingly unlikely that anything will go wrong with its internal arrangement, but if it does then the governor must be sent to the Edison factory for repairs.

No. 12.—To remove upper sprocket 26071, P. 1, screw out part 26074 and afterward you can pull off the sprocket.

Caution: Screw 26078, P. 3, carries a coil spring. When you remove the screw look out that you don't lose the spring.

Caution: Between the upper sprocket and the casting is a collar with 2 set screws which holds upper sprocket shaft in position. On reassembling don't fail to get this collar in place, or you will be unable to work the sprocket for setting the upper loop.

No. 13.—To remove gear 26025, P. 4, loosen the set screw in its hub and pull the shaft and upper sprocket out on the sprocket side. If the shaft starts hard, use a copper punch to drive it out.

Caution: Between the upper sprocket and the casting is a collar. In reassembling don't fail to get this collar in place.

No. 14.—The upper sprocket idler bracket 26082, P. 3, and its spindle may be released by taking out a small set screw in the face of the bracket.

Note.—This may never be necessary, as roller ends can be removed when worn without taking the bracket off.

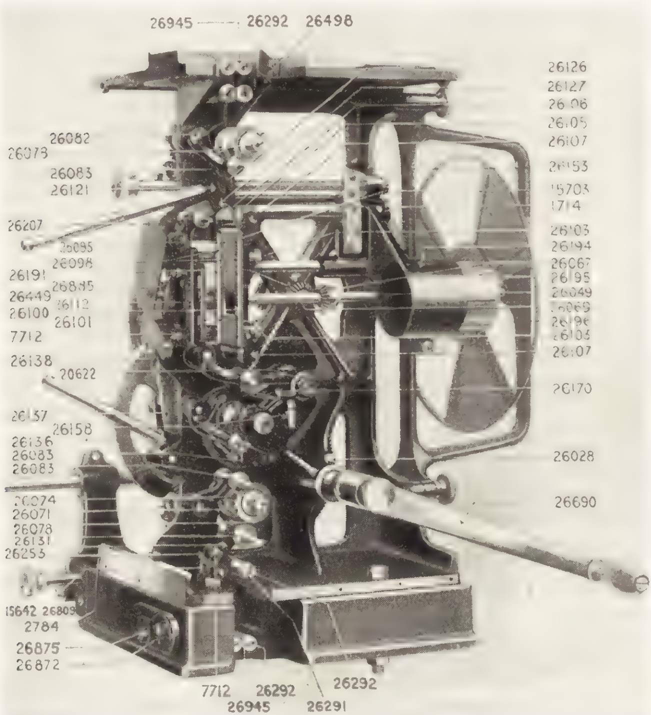


Plate 3, Figure 235.

No. 15.—There are two short shafts at either end of the casting, carrying a hardened double flanged roller. Either one may be removed independent of the other by loosening the set screw in the face of the bracket casting. The upper flange of these rollers rides on the sprocket. There is no way of adjusting their distance from the sprocket. There-

fore it is highly important that the tension supplied by the coil spring 26089, P. 2 (three of them), be neither too heavy nor too light. No explicit directions can be given except

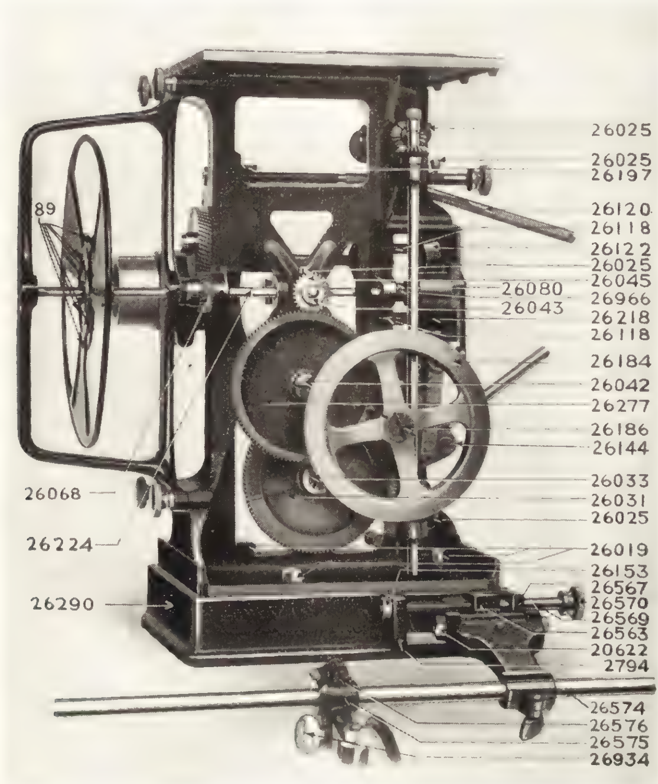


Plate 4, Figure 236.

that the spring should exert sufficient force to hold the idler in constant contact with the sprocket and with sufficient force to prevent the film from climbing the teeth.

No. 16.—The framing device, which consists of parts 26130 and 26131, P. 2, and parts 26138, 26137, and 26136, P. 3, accom-

plishes the framing of the picture by bending the film inward over the top of the intermittent sprocket. Rollers 26131 (two of them), may be removed by loosening the small set screw in the base of the casting and pulling outward on the roller. Each roller is mounted on a short spindle and is entirely independent of its mate. Part 26130, P. 2, which carries these rollers, may be removed by loosening the set screw in its hub and pulling outward on the casting. In replacing this part, be sure and get the point of the set screw entered into the countersink in the shaft. Otherwise the arm will not set right and the framing of the film will not be properly accomplished. The removal of part 26130, P. 2, also releases the spindle carrying it and the roller on the opposite side which is connected with the top of link 26137, P. 3, and by connecting the top end of the link the spindle and arm may be pulled out. The framing lever itself can be removed from the cast lug to which it is attached or the lug and the lever may be detached by taking out 26144, P. 4.

No. 17.—Film gate 26109, P. 1, is operated by gate lever 26120, P. 4. The raising of this lever closes the gate and locks it. Conversely, the lowering of the lever unlocks the gate and releases the film. The gate, its top roller, lever and link are shown, together with the aperture plate in detail in P. 5. The film gate and its assembled parts, as shown in P. 5, may be released from the mechanism as a whole by taking out screw 26121, P. 3, the screw which fits into hole X, P. 5, and loosening the small set screw in the lugs holding the front end of the two rods upon which the gate slides and driving the rods out, using a hard wood punch from the back end.

No. 18.—The aperture plate 26095, P. 3 and 5, is released by taking off knurled knobs (two of them) 26103, P. 1 and 5. The aperture plate tracks (see General Instruction No. 11) consists of a thin strip of highly tempered spring steel (26100 right, 26101 left, P. 5) held down by two metal strips 26098, P. 5. These strips may be removed by the simple process of taking out the eight screws which hold strips 26098, P. 5, in place, whereupon new strips, secured from the Edison Company, can be put in by being clamped under the metal strips.

Tension bars 26110, P. 5 and 1, are of hardened tool steel and should wear indefinitely. They are held in place by two guide screws, one of which is shown at 26112, P. 3, and are supplied with tension by two bow-shaped flat springs, one at the top and one at the bottom, upon which the points of screws 26885 (two of them) bear, 7712, P. 3, being the lock

nut of these screws. The tension on the film (see General Instruction No. 9) may be used at the will of the operator by adjusting screws 26885, P. 3. Should it ever become necessary to take out either one of the tension bars, 26110, P. 1, it may be done by removing screw 26112. This will release the tension springs also and they will drop out. The roller at the bottom of the aperture plate may be removed by taking out a small countersunk set screw in the center of the roller and pulling out pin 26107, P. 3. The same thing is also true of the roller at the top of the gate.

No. 19.—The motor driving the machine is controlled by a switch located underneath the machine, attached just in front of the lamphouse on the operating side. This switch is a special two-pole, single-throw switch and is held closed by means of a magnet. This magnet is only placed in operation when the machine is threaded so that the film holds the automatic stop 26131, P. 3, in an upright position. This stop rests against the film, and when in this position the magnet of the aforementioned switch is electrified and holds the switch in running position, but should the film at any time break, or at the end of the film, there being nothing to support automatic stop 26131, P. 3, it drops down, thus breaking the magnet's circuit and opening the motor switch, whereupon the machine instantly stops. This arrangement is entirely automatic in its operation.

The automatic stop as a whole may be released from the machine by taking off the set screws in the face of part 26253, P. 2, and pulling out spindle 26252, P. 1.

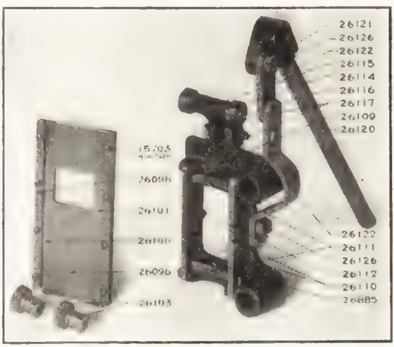


Plate 5, Figure 237.

No. 20.—Vertical drive shaft 26066, P. 2, may be pulled out from the top after releasing set screw 26025 (two of them), P. 2.

No. 21.—The general construction of the take-up tension is shown, assembled and in detail, in P. 6. The upright shaft

26519, P. 6, consists of an outer, hollow, and an inner, smaller, solid member, the tip of which is hardened and supports a small, steel ball 19957. Part 26503 rests upon and is supported by this steel ball and its top end connects with upright shaft 26066, P. 2. This shaft is supported at its lower end by a knurled knob 26513, P. 6, and by loosening lock nut 26022 and tightening up on knurled knob 26513, the tension of the take-up may be increased or, by slacking off on the knurled knob, the take-up tension may be decreased. The tension is supplied by friction with washer 26506, which is clamped between parts 26505 and 26503. The diameter of the friction disc is 2 15/16 inches.

No. 22.—The intermittent sprocket 26148, P. 2, is pinned to its shaft. It may be removed therefrom by taking out screws 26158, P. 3 (five of them), which releases the oil well cover, star, intermittent sprocket, sprocket shaft and collar. Next, with a small punch, carefully supporting the hub of the sprocket, drive out the pins and then loosen set screws in collar 26153, P. 2. You may then pull out the shaft and star, thus releasing the sprocket, and may substitute a new one. I would not, however, advise the operator to do this. The Edison Company assures me that it can send out the oil well cover, intermittent sprocket, shaft star (one piece), assembled, and that it will fit perfectly. This being the case, I would very strongly advise purchasers of Edison Super-Kinetoscopes to have an extra oil well cover with the parts it carries assembled all ready to put in. This would be comparatively inexpensive and would enable you to send the old part in to the factory, where the repair can be made in the best possible manner. It is a very delicate operation to install an intermittent sprocket and one which but few operators are equipped to do and do right.

The Edison intermittent movement is of the familiar star and cam type, both the star and cam pins being glass hardened, the grinding being done after hardening. The movement has, however, one exceedingly important peculiarity. It is "accelerated," or, in other words, made faster than such a movement would normally act so that the movement as assembled is a trifle faster than 6 to 1, which gives you a true 50-50 three-wing shutter, The mechanism which accelerates the movement is located behind the intermittent movement in the oil well. I am not going to give directions for the removal of this mechanism because I don't think it practical

for the operator to undertake it. He might get it out, but it is extremely doubtful that he would be able properly to reassemble the parts. The accelerating movement runs in oil and it is extremely unlikely that it will require any attention until the whole mechanism is sufficiently worn to require being sent back to the factory for overhauling.

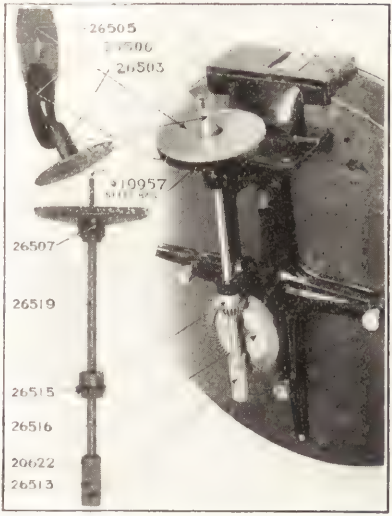


Plate 6, Figure 238.

No. 23. — Adjusting the intermittent movement. (See General Instruction under No. 5.) The adjustment of the star and cam is accomplished by loosening heavy round headed set screw 26170, P. 3, just back of the intermittent movement oil well cup and then shifting lever 26169, P. 2. If you raise the lever 26169 up, you tighten the movement and conversely by lowering it you loosen the movement.

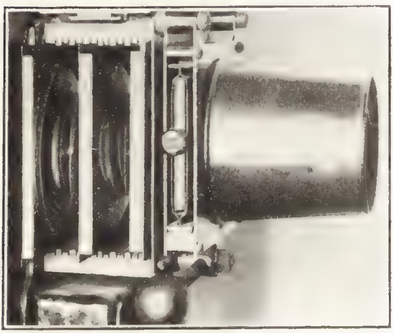


Plate 7, Figure 239.

Caution: Don't forget to tighten up set screw 26170 when you get through.

No. 24.—The intermittent movement oil well is fed by oil cup 26164, P. 1. This cup should be kept level full. (See General Instruction No. 1.) At the bottom of the oil well is a drain, and once each week the operator should clean the oil well out and fill it with oil. Once a month it

would be a good plan to drain out the oil well and fill it with kerosene and run the machine say one-half a minute, after which drain out the kerosene and refill with oil.

No. 25.—Lens ring adapters. Lens carrier 26194, P. 3, is fitted with a metal lining called an "adapter." These adapters are furnished in three styles, accomodating any standard lens.

No. 26.—Revolving shutter 26247, P. 1, may be removed from the mechanism simply by taking out thumb screws 26245 (four of them), P. 5. In assembling be sure to get casting 26243, P. 1, right side up so that the shutter spindle fits into the right ends of the lower three gears as you stand facing the lens in the machine. It is possible to turn the casting the other way to fit the shutter of the other gear, but this is only designed for special purpose which will be explained by the Edison Company upon request.

For setting the shutter, see General Instruction No. 18.

Plate 7 shows the construction of the condenser holder, and the means for spacing the lens.

Parts on Plate No. 1.

26494	Mechanism upper fire door.
26025	Upper sprocket shaft oil cup with tube.
26074	Upper sprocket coupling with pin.
26071	Upper sprocket.
26205	M. P. lens holder adj. screw knob
79	M. P. obj. lens holder feed nut spring screw.
26114	Film gate tension roller.
26115	Film gate tension roller bracket.
26117	Film gate tension roller bracket spring.
26116	Film gate tension roller bracket pin.
26200	M. P. obj. lens adapter ring locating screw.
26927	Ext. rev. shutter hub.
26968	Rev. shutter main shaft helical gear set screw.
26068	Rev. shutter main shaft gear.
26109	Film gate.
26110	Film tension bars.
26111	Film tension spring.
26135	Framing device adj. rod.
26164	Cam crank shaft barrel oil cup with holder.
7044	M. P. obj. lens feed nut spring adjusting screw.
2782	M. P. obj. lens holder feed nut screw.
1714	M. P. obj. lens holder slide rod set screw.
26245	Ext. rev. shutter shaft bracket screws.
26243	Ext. rev. shutter shaft bracket.
26204	M. P. obj. lens holder adjusting screw.
26968	M. P. lens holder adj. screw collar set screw.
26198	M. P. obj. lens holder feed nut spring.
26199	M. P. obj. lens holder feed nut spring guard.
26202	M. P. obj. lens holder upper slide rod.
26270	Ext. rev. shutter inter. gear with hub.
26275	Ext. rev. shutter intermediate gear stud.
26247	Ext. rev. shutter assem.
26201	M. P. obj. lens holder lower slide rod.
13	Ext. rev. shutter flange screws.
26928	Ext. rev. shutter clamping flange.
26239	Ext. rev. shutter shaft.
26926	Ext. rev. shutter blade holder.
26245	Ext. rev. shutter shaft bracket screws.

Parts on Plate No. 2.

26459	Vertical drive shaft knob.
26191	Vertical drive shaft mitre gear.
26025	Vertical drive shaft oil cup with tube.
26066	Mechanism vertical drive shaft.
20622	Stereo. lens holder hinge screw nut.
26580	Stereo. lens holder.
18419	Stereo. lens adapter ring.
26277	Large inter. gear with first inter. pinion and pin.
26169	Cam shaft barrel lever.
18432	Stereo. lens adapter ring stop screws.
43	Cam shaft barrel lever screw.
26025	Cam crank shaft oil cup with tube.
26130	Inter. sprocket tension roller bracket.
26178	Cam crank shaft gear. assembled.
26576	Stereo. lens holder hinge screw.
26577	Stereo. lens holder support and rod assem.
26188	Take-up sprocket shaft mitre gear with pinion and pin.
26934	Stereo. lens slide rod clamp screw.
26191	Vertical drive shaft mitre gear.
26025	Vertical drive shaft oil cup with tube.
26562	Stereo. lens bracket.
26572	Stereo. lens bracket stop screw.
7084	Stereo. lens bracket stop screw nut.
26564	Stereo. lens bracket hinge bolt.
26566	Stereo. lens bracket slide rod.
26578	Stereo. lens holder support.
26089	Upper tension roller bracket spring.
26969	Upper tension roller bracket set screw.
2798	Upper tension roller bracket spring screw.
26022	Mechanism head.
26289	Upper tension roller bracket stud with head.
26085	Upper tension roller stud (long).
2347	Upper tension roller stud set screw.
26085	Film gate tension roller stud (long).
26073	Rev. shutter main shaft end plate screws.
26061	Rev. shutter main shaft end plate with bushing and pins.
26131	Framing device roller.
26105	Aperture plate lower roller body.
26969	Framing device roller bracket screw.
26093	Aperture plate roller ends.
26130	Framing device roller bracket.
26969	Inter. sprocket roller bracket set screw.
26149	Inter. sprocket bracket with bushing.
26148	Inter. sprocket.
26153	Star wheel shaft collar.
26152	Star wheel with shaft.
26085	Inter. sprocket tension roller stud (long).
26155	Inter. sprocket bracket adapter plate.
2347	Tension roller stud set screw.
26035	Driving crank coupling.
26037	Driving crank stop screw.
26085	Take-up tension roller stud (long).
26091	Take-up tension roller bracket.
26025	Take-up sprocket shaft oil cup with tube.
26086	Take-up tension roller bracket stud with head.
26085	Motor stop roller stud (long).
26969	Take-up tension roller bracket set screw.
26260	Motor stop roller bracket spring.
2798	Take-up tension roller bracket spring screw.
26089	Take-up tension roller bracket spring.

Parts on Plate No. 3.

26082	Upper tension roller bracket.
26078	Upper sprocket clutch screw.
26083	Upper tension roller.
26121	Film gate shift rod bracket.
26207	Auto. drop shutter with counterbalance.
26095	Aperture plate and studs, assem.
26098	Film guide.
26191	Mitre gear.
26885	Film tension spring screw.
26499	Auto. drop shutter screws.

26112 Film tension bar screw.
26100 Film spacer (right).
26101 Film spacer (left).
7712 Film tension spring screw lock nut.
20622 Large inter. gear stud nut.
26138 Framing device link stud knurled nut.
26137 Framing device adj. rod link.
26158 Inter. sprocket bracket screws (long).
26136 Framing device adj. rod bracket.
26083 Inter. sprocket tension roller.
26083 Take-up tension roller.
26074 Take-up sprocket coupling with pin.
26071 Take-up sprocket.
26078 Take-up sprocket clutch screw.
26131 Motor stop roller.
26253 Motor stop roller bracket.
15642 Motor stop arm stop screw.
26809 Motor stop arm with tip.
2794 Mechanism case left corner plate screws.
26875 Motor stop push button socket.
26872 Motor stop push button.
7712 Motor stop arm stop screw lock nut.
26945 Magazine film guide rollers.
26292 Magazine film guide roller shaft.
26291 Lower film guide roller.
26292 Lower film guide roller shaft.
26498 Mechanism upper fire door hinge screw.
26126 Film gate shift rod link screw (large).
26127 Film gate shift rod link screw (small).
26105 Aperture plate upper roller body.
26106 Aperture plate upper roller ends.
26107 Aperture plate upper roller shaft.
26153 M. P. lens holder adj. screw collar.
15703 Film guide screws.
1714 M. P. obj. lens holder slide rod set screw.
26103 Aperture plate clamping nuts.
26194 M. P. obj. lens holder.
26067 Rev. shutter main shaft mitre gear.
26195 M. P. obj. lens adapter ring.
26049 Rev. shutter main shaft mitre gear screw.
26069 Rev. shutter main shaft.
26196 M. P. obj. lens adapter ring clamp screw.
26103 Aperture plate clamping nuts.
26107 Aperture plate lower roller shaft.
26170 Cam shaft barrel set screw.
26028 Cam crank shaft oil cup.
26690 Driving crank assem.

Parts on Plate No. 4.

89 Ext. rev. shutter blade screws.
26068 Ext. rev. shutter countershaft gear.
26224 Ext. rev. shutter countershaft.
26277 Large inter. gear with first inter. pinion and pin.
26042 Large inter. gear stud.
26031 Mechanism driving gear.
26033 Mechanism driving gear screw.
26290 Mechanism base.
26574 Stereo. lens holder slide rod.
26153 Stereo. lens bracket adj. screw collar.
26575 Stereo. lens holder support rod bracket.
26934 Stereo. lens holder support rod clamp screws.
26576 Stereo. lens holder hinge screw.
2794 Stereo. lens slide bracket rod set screw.
20622 Stereo. lens slide bracket hinge bolt nut.
26197 M. P. obj. lens holder feed nut.
26025 Vertical drive shaft oil cup with tube.
26120 Film gate shift rod.
26118 Film gate slide rod.
26122 Film gate shift rod link, assem.
26025 Ext. rev. shutter countershaft oil cup with tube.
26045 Second inter. pinion, assem.
26080 Rev. shutter main shaft collar.
26966 Rev. shutter main shaft collar set screw.
26043 Second inter. pinion shaft assembled.
26218 Auto. drop shutter clutch cover.

26118	Film gate slide rod.	26567	Stereo. lens bracket base.
26184	Cam crank shaft pulley.	26570	Stereo. lens bracket adj. screw knob
26186	Cam crank shaft pulley screw.	26569	Stereo. lens bracket adj. screw.
26025	Vertical driver shaft oil tube.	26563	Stereo. lens bracket slide.
26019	Mechanism head bolts.		

Parts on Plate No. 5.

26114	Film gate tension roller.	26117	Film gate tension roller bracket spring.
26115	Film gate tension roller bracket.	26120	Film gate shift rod.
26116	Film gate tension roller bracket pin.	26122	Film gate shift rod link, assem.
26117	Film gate tension roller bracket spring.	26126	Film gate shift rod link screw (large).
26109	Film gate.	26110	Film tension bars.
26111	Film tension spring.	26103	Aperture plate clamping nuts.
26112	Film tension bar screw.	26096	Aperture plate.
26110	Film tension bars.	26098	Film guide.
26885	Film tension spring screw.	26100	Film spaced (right).
26121	Film gate shift rod bracket.	15703	Film guide screws (8 of them).
26126	Film gate shift rod link screw (large).		
26122	Film gate shift rod link, assem.		

Power's Six-B Mechanism

THE Power's No. 6 Mechanism is of the "open" type in that it has no protecting casing. Thus all the gears and machinery are directly under the eye of the operator. In referring to these instructions the numbers refer to parts and plates. Thus: 738, P. 2, means that the part indicated is shown in Plate 2, which in this case is the screw holding the upper and the lower sprockets to the shaft.

No. 1. Removing Main Driving Gear and Spindle.—To remove main driving gear 630, P. 4, and its spindle 631, P. 4 and 7, first remove crank 632, P. 5, and taper pin, 795, P. 2, which engages the slot in the hub of the crank. This is a taper pin and in the later machines a prick punch mark will be found on the end of shaft 631 P. 4. This mark is opposite the large end of the pin. Having removed this pin, the shaft and gear may be withdrawn, and, if desired, the gear may be removed from the shaft by taking out the taper pin in its hub.

No. 2. To Remove Shaft 618, P. 4, Carrying Gears 620 and 619, P. 4, first follow Instruction No. 1, then loosen screw 738, P. 2, backing it off some distance, as it is countersunk into the shaft, whereupon the shaft and gear may be withdrawn from the gear side.

No. 3. Removing Automatic Fire Shutter Governor Cover.—To remove automatic fire shutter governor cover 623, P. 2, loosen screw 718, P. 2, backing it off somewhat, as it is

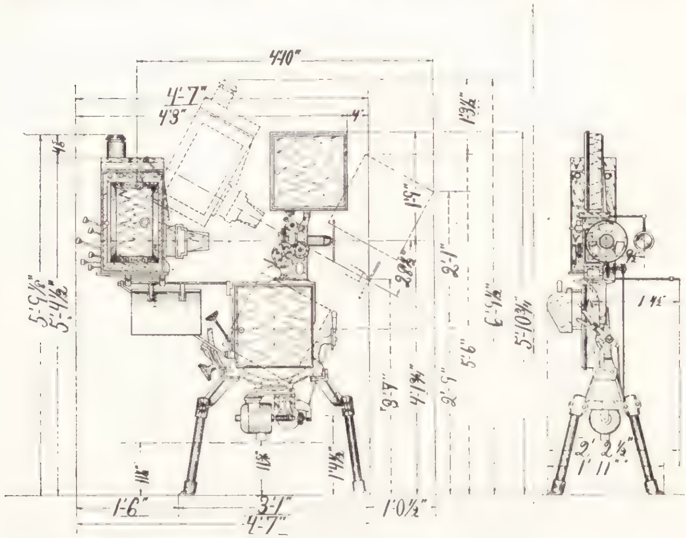


Figure 240.

countersunk into the shaft. This releases cover 623 (also shown at the left in Plate 8). If the cover does not readily pull off, tap gently on the end of the shaft, at the same time pulling on the cover.

Caution: Don't try to pry the cover off by inserting a screwdriver point between part 623 and 624, P. 2. If you do you will probably merely succeed in ruining your governor.

No. 4. To Remove Friction Casing of Automatic Fire Shutter, 624, P. 2.—Follow Instruction No. 3, then remove screw 785, P. 7, whereupon part 624 may be pulled away.

No. 5. To Remove Automatic Fire Shutter Link 628 and Lever 627, P. 7, follow Instruction Nos. 3 and 4, after which the parts are released by taking out a screw on the back side of part 624.

No. 6. Adjusting Fire Shutter Governor.—Should automatic fire shutter blade 697, P. 1, fail to drop, examine lever 627, and link 628, P. 7, and see that they work freely and are

not bent. Usually the binding of these parts is responsible for the sticking of the fire shutter. If this is not found to be the seat of the trouble, remove cover 623, P. 2 (see Instruction No. 3), and carefully examine springs 741, P. 8; also examine the inside edge of friction casing 624, P. 2, and see if track "Y," Fig. 8, is smooth, as it should be, and not

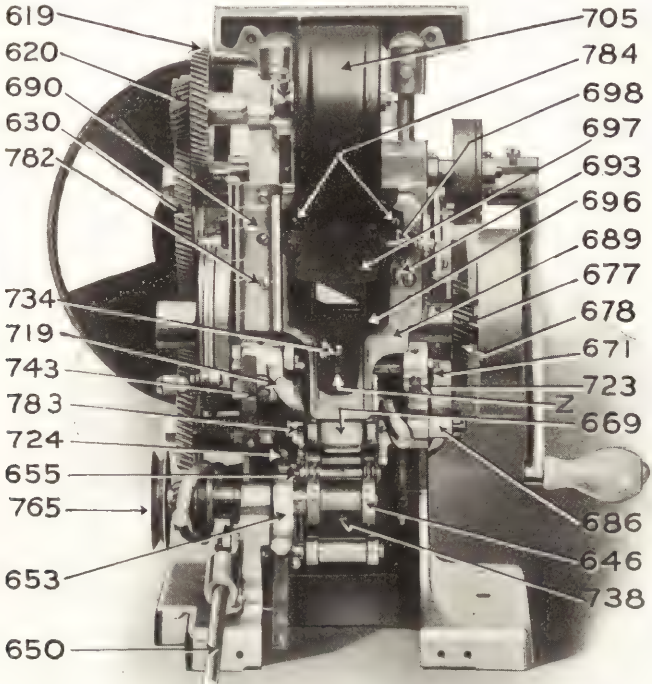


Plate 1, Figure 241.

scratched or rough. If it is rough or scratched, carefully polish track "Y" by using No. 00 emery cloth.

Caution. Do not use coarse emery cloth, or you will only succeed in making matters worse.

Should the automatic fire shutter fail to raise properly,

first try injecting a drop of *heavy* oil in the oil hole on top of part 624, P. 2. The clutch shoes, 625, P. 8, act by centrifugal force, which throws out weights 626, P. 8, against the action of springs 741, P. 8, thus forcing friction shoes 625 against track "Y," P. 8. The friction thus engendered revolves casing 624 in clockwise direction, thus forcing lever 627, P. 7, ahead and raising shutter flap 697, P. 1. Don't use thin oil on the automatic shutter governor, as it tends to reduce the friction too much. Use heavy oil and use it sparingly. Should the fire shutter raise too quickly, or should the governor develop undue friction, thus making the mechanism pull hard, it will probably be found that springs 741, P. 8, have become weakened. This may be remedied by installing new springs, or stretching the old ones. Another possible cause of failure of the fire shutter to act, or to act too slowly, is the binding of the screws at the top or lower end of link 628, P. 7. This link must swing perfectly free. In the center and top of fire shutter flap 697, P. 1, is a pin. This pin not only serves to hold the flap to its spindle, and prevent its slipping circumferentially, but it also prevents the shutter from raising too high. Therefore, it should not be allowed to become loose and fall out. Automatic shutter governor counterweight 629, P. 2, should be kept set in such manner that it stands about half-way between the horizontal and perpendicular, when the shutter flap is down, leaning outward toward the lamphouse.

No. 7. Removing Top Roller Bracket.—Top roller bracket 612, P. 2 and 7, may be removed by taking out stud 720, P. 7.

No. 8. Removing Top Sprocket Idler.—Top sprocket idler 609, P. 2, may be removed by loosening screw 721, P. 2, pulling the shaft out and taking off the collar next the roller. These rollers should be renewed if there is any indication of flat spots on their surface.

No. 9. Removing Top and Bottom Sprockets.—Top sprocket 617, P. 7, and lower sprocket 646, P. 2, may be removed simply by loosening the set screw in the center of their hub, pulling the sprocket off the shaft. (See General Instructions Nos. 3 and 4.)

In the later machines there is a metal guard which comes up between the flanges of the upper sprocket. In order to remove this sprocket it will be necessary first to take off this guard, which may be accomplished by the removal of two screws, one in either of its lower corners.

No. 10. Tension of Upper Idler Bracket.—Upper sprocket idler 609, P. 2, is held to the sprocket by flat spring 615, P. 2.

Should this spring at any time become too weak, it may be strengthened by removing the idler bracket (see Instruction No. 7) and bending the top of the spring outward until the desired tension is obtained.

No. 11. Removing the Gate.—The entire gate, including cooling plate 696, P. 1, automatic fire shutter flap 697, P. 1, and hinge 690, P. 1, may be removed by taking out screws (three of them) 782, P. 1. In replacing the gate, before tightening up screws 782, P. 1, be sure that the top gate idler rollers 691, P. 3, center properly with the aperture plate. After replacing the gate, project white light to the screen. If there is a shadow at the top, bottom or side, open the gate. If the opening of the gate removes the shadow, then it means that you haven't your gate properly centered, and you must loosen hinge screws 782, P. 1, and move the gate until the shadow disappears, being careful, however, that the upper idlers 691, P. 3, are kept spaced equidistant from the sides of the aperture plate.

No. 12. Removing and Adjusting Tension Shoes.—Tension shoes 790, P. 2, may be removed by first pulling out the pin in gate hinge 690, P. 1, after which remove screws 789 (one on either side), P. 2. This releases the tension shoes.

No. 13. Removing Tension Springs.—Between the face of the gate and cooling plate 696, P. 1, are the tension springs and the tension spring equalizer. Should it at any time be necessary to remove either of these, take out two flat head screws just above and below the cross bar joining tension shoe tracks 790, P. 2. This will release cooling plate 696, P. 1, and expose the parts. In replacing, be sure that the little flat spring which acts on gate latch 693, P. 1, rests against the latch, and *not* on top of it.

No. 14. Removing Cooling Plate.—(See Instruction No. 13.)

No. 15. Adjusting Tension.—(See General Instruction No. 9.) The tension is governed by screw 734, P. 1. Setting this screw inward increases the tension, and conversely, backing off on the screw decreases it.

No. 16. Aperture Plate.—Aperture plate 687, P. 2, may be taken off by removing screws 713 (four of them), P. 2, and pulling the plate away. In replacing the aperture plate, proceed as follows: Put the plate in place and insert the four screws holding it, tightening them down just enough so that by tapping lightly on the edge of the plate it may be moved either way. Now project the white light to the screen and move the aperture until the upper and lower

lines of the light are level on the screen, whereupon tighten up the four screws *tight*.

Caution.—In removing parts of this kind, remember that the screws are small. Don't drop them or lay them

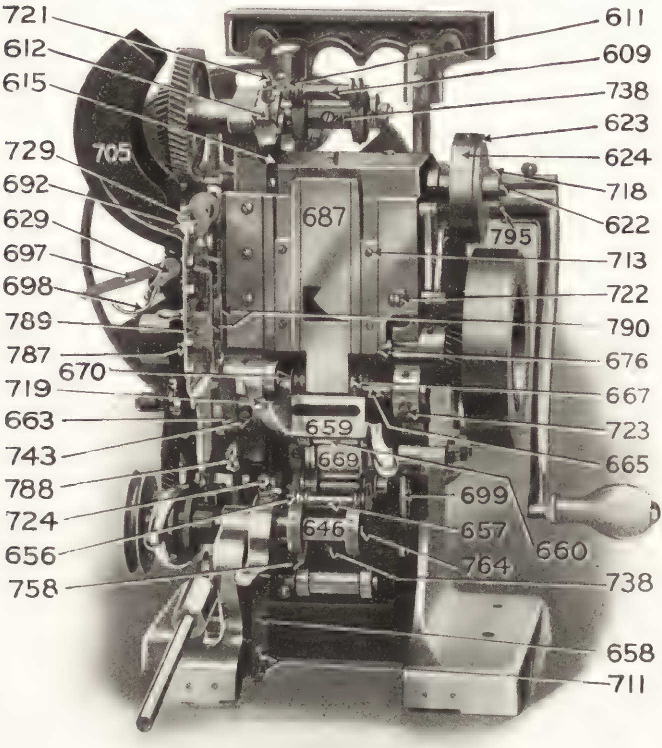


Plate 2, Figure 242.

down anywhere, depending upon luck to find them again. Have a cigar box or some small receptacle in which to place all screws, or in lieu of that replace the screws in the holes when you take the part away. Then you will know where they are when you want them. A magnetized screwdriver

is a fine thing with which to handle small screws. (See General Instruction No. 19.)

No. 17. Adjusting Gate Latch Screw.—The right-hand edge of the face of the gate and its left-hand edge should set an equal distance away from the face of the machine casting, since otherwise the tension on one shoe will exert greater pressure than it will on the other. This is regulated by gate latch screw 722, P. 2. This screw should be set in a sufficient distance to bring the entire gate square with the face of the mechanism casting, and the lock nut thereon should then be set up tight to prevent any possibility of change in this adjustment.

No. 18. Removing Intermittent Roller Bracket.—Roller bracket 659, P. 2, may be removed by taking out the screw in its hinge, first, however, having loosened screws 788, P. 2, holding spring 663, P. 2. The distance of the idler which this bracket carries from the intermittent sprocket (see General Instruction No. 12) may be varied by tightening or loosening screw 719, P. 2. To accomplish this, first loosen the nut on its outer end, then turn the bracket clear up, and the head of the screw will be found underneath. The further this screw is backed out, the further the roller will be from the sprocket, and vice versa. The tension of this bracket is governed by flat spring 663, P. 2. This may be made greater or less by bending the spring. If it is to be made greater, remove the spring for bending. If it is to be made less, just bend the upper end of the spring outward, but be careful not to bend it too much.

No. 19. Removing and Adjusting Apron.—Apron 669, P. 1, may be taken off by removing two screws (one at either side) near the rollers at its lower end. The adjustment of this apron is quite important. Should the film make a chattering sound in going through the machine, carefully bend the ears at the lower end of apron 669, P. 1, which carry the rollers, ahead slightly, being careful to bend each one the same amount. If this remedies the trouble, well and good. If it helps but does not remedy it then try bending them a little more. If this makes it worse bend the rollers back slightly. You can do no damage by bending these apron ears, provided you keep the rollers square with the sprocket, that is to say equidistant from the sprocket. To test this, measure from the face of each hub of the roller to opposite teeth on the lower sprocket.

No. 20. Removing and Adjusting Lower Sprocket Idler Bracket.—Lower sprocket idler bracket 653, P. 1, may be re-

moved merely by taking out its hinge screw, first, however, loosening screws 711, P. 2, holding flat spring 658. The distance of the roller which this bracket carries from the sprocket (see General Instruction No. 12) is determined by the position of screw 724, P. 2. Spring 658, P. 2, should supply sufficient tension to this bracket to hold it firmly in place when it is

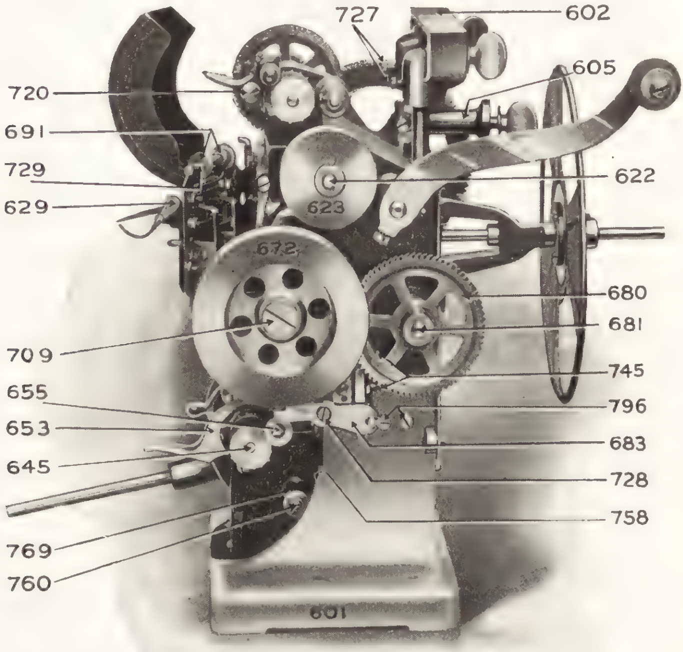


Plate 3, Figure 243.

closed down, but this may be overdone. The tension should not be sufficient to cause the sprocket teeth to punch through, or even seriously indent the film when it climbs the sprocket. This adjustment calls for a little judgment and common sense. If it is too loose the loop setter will work overtime. If it is too tight damage may and probably will be done to the film.

No. 21. **To Remove Fly Wheel** 672, **P.** 3, remove screw

709, P. 3. If you cannot start this screw with an ordinary screwdriver, grind down the broad end of a file to make a screwdriver for the purpose. Having removed this screw, place the point of the screwdriver right up close against the hub on the opposite side of the wheel, and tap gently until the wheel becomes loose. In replacing the fly wheel be sure that groove 746 in pinion 677, P. 7, connects properly with the dowels on the spindle. In order to accomplish this insert the point of the screwdriver between lugs carrying brackets 659, P. 2, and the collar on shaft 676, P. 2, and pry gently downward. This will hold the spindle stationary while you twist the wheel until the slots and dowels come opposite each other.

Caution: Between pinion 677, P. 7, and the hub of the casting it fits up against is a thin steel washer. *This washer fits on the larger diameter of the shaft,* and you must be careful that it is precisely in place before the wheel is forced on, or you will have trouble. When the wheel is in place, tighten up screw 709, P. 3, tight.

No. 22. **Removing Toggle Gear.**—To remove toggle gear 678, P. 1 and 7, follow Instruction No. 21, then loosen the screw in the upper end of connecting link 682, P. 7, backing it out for a considerable distance, since it is countersunk into the shaft, whereupon the gear and spindle may be pulled out. The adjustment of this gear is a very important matter. The gear must be exactly centered between fly wheel pinion 677, P. 1, and gear 680, P. 3. The toggle gear is carried by connecting link 682, P. 7, and its position with relation to the gears on either side of it is determined by the position of the casting carrying the horizontal bar. Should a grind develop in this gear, first having made sure that connecting link 682, P. 7, is held snugly in its ways by casting 685, P. 7, using a soft metal punch, tap lightly first one way and then the other against casting 684, P. 7, the idea being to slip the casting slightly against the pressure of the screws which hold it. The casting cannot be moved much, but sometimes enough movement may be accomplished to remove or reduce a grind.

No. 23. **Adjusting Connecting Link.**—Connecting link 682, P. 7, plays an important part, and must be kept tight in its ways. If by shaking horizontal bar 683, P. 7, you are able to move connecting link 682 in its ways, then it is too loose, and may be tightened as follows: First loosen screws 745, P. 7, slightly. Then tighten up just a little on screws 744 (two of them), P. 7, retighten screws 745 and

try the framing lever. If it works too hard, you have moved screws 744 too much. If it is still too loose, then you can give them a little bit more, but be careful and do not get them too tight or your framing carriage will bind. In making this adjustment, do not set screws 744 in so much that the

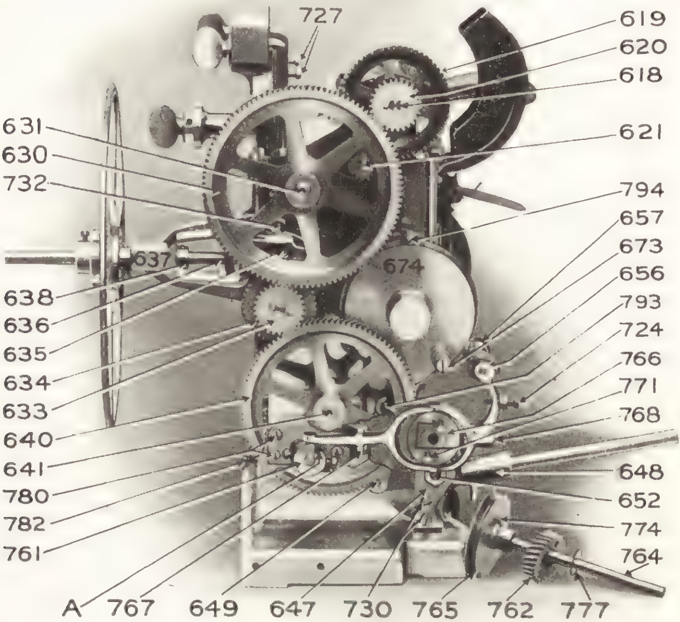


Plate 4, Figure 244.

connecting link fits snugly while screws 745 are loose, for if you do when you tighen screws 745, the whole thing will be clamped solid. When you get through with this job, be sure that screws 745 and the lock-nuts on screws 744 are set up tight.

No. 24. **Removing Lower Sprocket Shaft.**—To remove lower sprocket shaft loosen screw 738, P. 1, and pull.the shaft out to the left..

No. 25. **Removing Large Idler Gear.**—To remove large

idler gear 640, P. 4, remove the mechanism from the machine table, turn it bottom side up and looking in you will see the shaft which holds this gear, and on it, right up against the machine casting, a brass collar, the stock number of which is 642. Revolve the fly wheel until the set screw in this collar comes into view. Loosen the set screw and you may then pull the gear and its shaft out.

No. 26. **Removing the Loop Setter.**—Loop setter fork 768, P. 4, may be removed by first following Instructions Nos. 24 and 25. Then remove screw 767, P. 4, which will release the fork and clutch 766, P. 4. Loop setter cam 761, P. 4, is removed by following Instructions 24 and 25, loosening the two large screws in its face and pulling it off the shaft. Should it be necessary to remove the loop setter arm, carrying roller 769, P. 3, or the spring which provides tension therefor, first follow Instructions 24 and 25; then loosen screws 780 (three of them), P. 4. Having removed these screws, the entire arm, including roller 769, P. 3, may be pulled out through the hole in the machine casting. The replacement of these parts is merely a reversal of the process of their removal, but in replacing them, be sure that all screws, particularly screws 780 and the screws in cam 761, be set up tight. In replacing the loop setter, be careful that roller 769, P. 3, lines properly with the lower sprocket, or, in other words, that the roller sets perfectly "square with the film," since otherwise when the loop setter acts the pull will be all on one side of the film, which may and probably will cause trouble.

No. 27. **Adjusting the Loop Setter.**—Screw 782, P. 4, is for the purpose of adjusting or regulating the throw of loop setter arm and roller 769, P. 3. This screw should be so adjusted that roller 769, P. 3, rests about half-way between the lower sprocket and the top of the front cross bar in the base of the machine.

No. 28. **The Shutter Bracket.**—When a new machine is received, shutter bracket 637, P. 4, will be folded down against the mechanism and shutter blade 700, P. 6, will be tied to the mechanism. Raise up shutter bracket 637, P. 4, until it is in a horizontal position, as shown in plate 4, and screw 732, P. 4, has engaged the hook on the upper part of the bracket, first having backed screw 732 out sufficiently so that the hook will pass in behind its head. Now, having raised the bracket clear up, tighten screw 732, P. 5, *tight,* and then tighten screw 733 *tight.*

Caution: Do *not* tighten screw 733 until you have tight-

ened screw 732, because if you do it will probably cause the shutter spindle to bind in the bracket. The entire shutter bracket, 637, P. 4, may be removed from the machine by first following Instructions Nos. 1, 24 and 25, and loosening

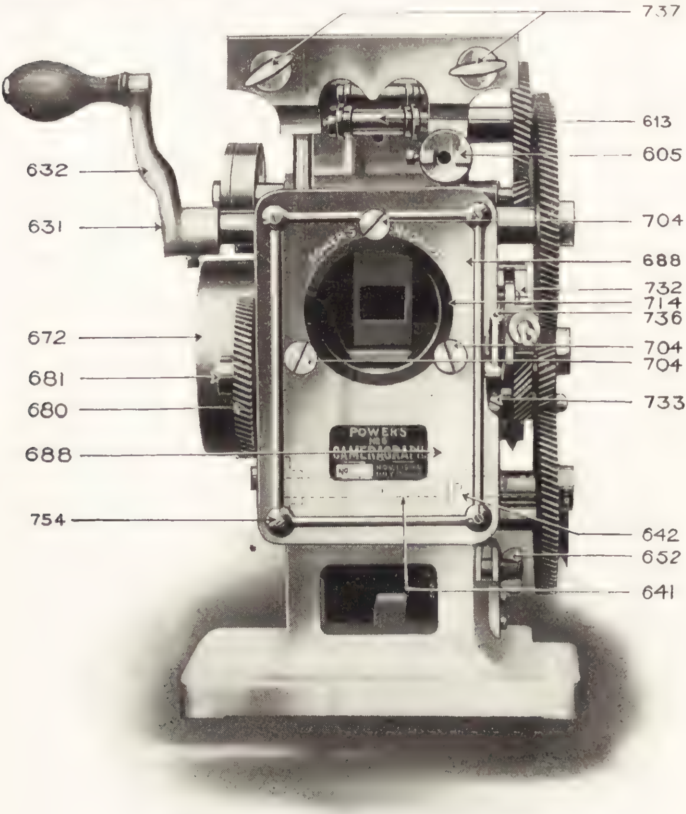


Plate 5, Figure 245.

screw 732, P. 4, and 733, P. 5. Then drive out the taper pin in the hub of gear 680, P. 3, and drive out shaft 681, P. 3, carrying with it, on the opposite end, gear 633 and 634, P. 4. To drive this spindle out, use a heavy nail or a center punch.

No. 29. Removing Shaft 681, P. 3, and Gears 633 and 634, P. 3.—See Instruction No. 28.

No. 30. Installing Shutter Driving Gears 633, 634, and 635, P. 4.—*Do not attempt it.* If these gears need replacing, it will be necessary to send the machine to the factory, or to a *thoroughly* competent repair man. The same applies to the shutter shaft 636, P. 4. It would be hardly possible for the operator to replace either gears 633, 634, or 635, or to put in a new revolving shutter shaft, and get the parts so adjusted that they would run right.

No. 31.—In P. 6 we see a three-blade shutter. This blade may be changed to a two-blade, using the same hub, by loosening screw 740, P. 6, pulling the shutter off its shaft and removing three screws in the back of its hub. This releases the shutter blade, which may then, if desired, be changed to another one of different design.

No. 32. Setting the Shutter.—(See General Instruction No. 18.) Shutter 700, P. 6, may be set by loosening screws 739, P. 6, in its hub, which will allow the outer hub to revolve on the inner, thus enabling the operator to set the shutter in any desired position.

No. 33. Removing Oil Casing Cover.—To remove oil casing cover 674, P. 4, follow Instructions Nos. 24 and 25. Next remove screws 794 (three of them), P. 4, and tap lightly on the hub of the cover to break the shellac joint.

In replacing this cover scrape the edges lightly, being sure to get them perfectly clean. Then smear edge of the cover (*not* casing edge, but the cover edge *only*) with thick shellac, to be had of any painter, and clamp the cover in place. It is better if the shellac dries a little before you put the cover on, but don't let it dry too much.

Caution: *Don't put on too much shellac.* If you do, it will squeeze out into the interior of the oil casing and get between the pins and the cam, thus doing serious injury to the intermittent movement. Instances have been known where an excess of shellac has broken a geneva pin.

No. 34. Removing Cam Shaft and Cam.—First follow Instructions Nos. 21, 24, 25 and 33. Then loosen the two set screws in the collar on shaft 676, P. 2, just above arrow head 670, P. 2, move the collar over to the right and, with a small, *fine* file, smooth off the burrs caused by the set screws. The shaft and cam may then be pulled out to the left.

Caution: In replacing this shaft, don't forget to put the collar on.

No. 35. **To Remove Intermittent Sprocket.**—To remove the intermittent sprocket, follow Instructions 19, 21, 24, 25, 33, and 34. Next loosen screw 743, P. 2, and the entire sprocket, its shaft and the large left-hand bushing and cross may be pulled through the oil well.

No. 36. **Replacing Intermittent Sprocket.**—This is a thing

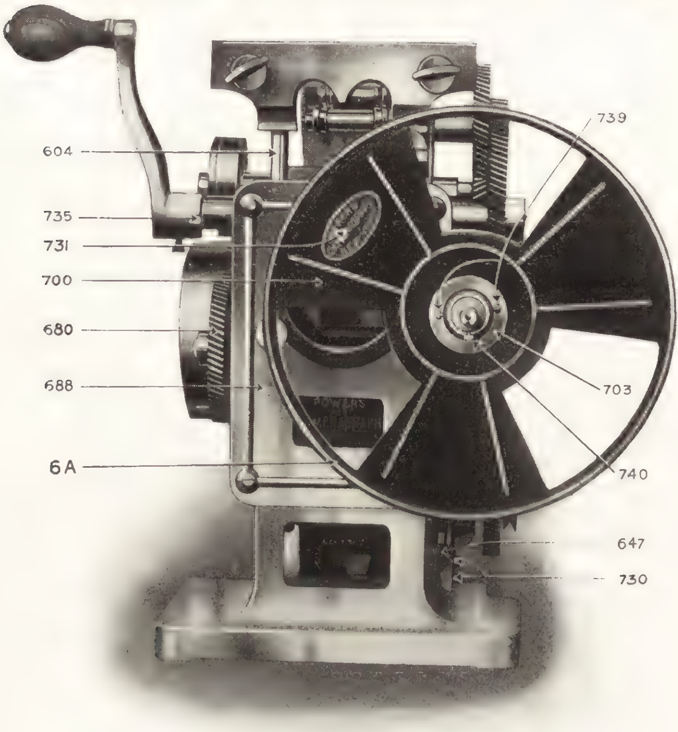


Plate 6, Figure 246.

I by no means advise the operator to attempt. The intermittent sprocket of a projector might be termed the "heart" of the machine. It is imperative that the sprocket itself and its fitting upon the shaft be accurate within one ten-thousandth of an inch. It is, of course, possible that the

operator *might* fit a sprocket to the shaft in such way that it would produce perfect results, but it is hardly to be expected. I would by all means advise the manager to purchase an extra cross, shaft, intermittent sprocket and large bushing, assembled, and all ready to slip into the machine. Then, instead of taking chances on fitting a sprocket, you can slip the old one out, as per the foregoing instruction, install the new one, and for a few cents send the old one to the factory by

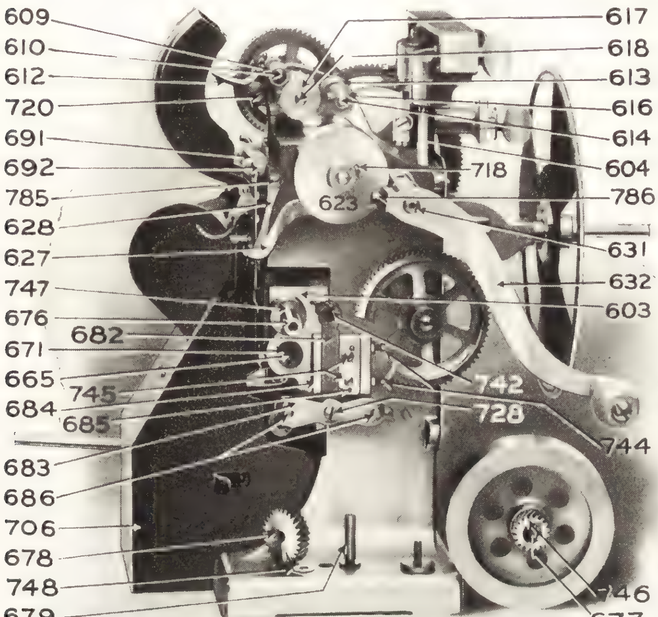


Plate 7, Figure 247.

insured parcel post and have a new sprocket fitted on properly, thus insuring perfect results on the screen. In this connection see last part of General Instruction No. 5.

I would go further than this and recommend to the theatre manager that he purchase a complete extra framing carriage, so that in event of wear in the intermittent movement,

worn intermittent sprocket teeth, bushing or shafts, the entire framing carriage may be removed (see Instruction No. 37), and the new one substituted. You may then send the framing carriage to the factory by insured parcel post, at a merely nominal transportation fee, and it will be returned to you in perfect condition, thus insuring you against any possibility of bad results on the screen through improper fitting of these extremely delicate parts.

No. 37. Removing the Framing Carriage.—To remove the entire framing carriage of the mechanism, first remove the aperture plate (see Instruction No. 16) and the gate (see Instruction No. 11). Next remove screw 793, P. 4, in top end of framing lever link, turn the machine around, and looking through the lens hole you will see two perpendicular rods, the top ends of which are held in cast lugs. Loosen the set screws in these lugs and in similar lugs at their lower ends, and pull these perpendicular rods out from below. Next remove horizontal bar 683, P. 3, by taking out screw 728, P. 3. The carriage may then be taken from the machine.

No. 38. Care of Sprockets.—(See General Instructions Nos. 3 and 4.)

No. 39. .Oil.—(See General Instruction No. 1.)

POWER'S SIX B, SPEED CONTROL

The entire output of Power's projection machine stands of the later types are drilled to receive the Power's Speed Control. When the machine is received, the speed control

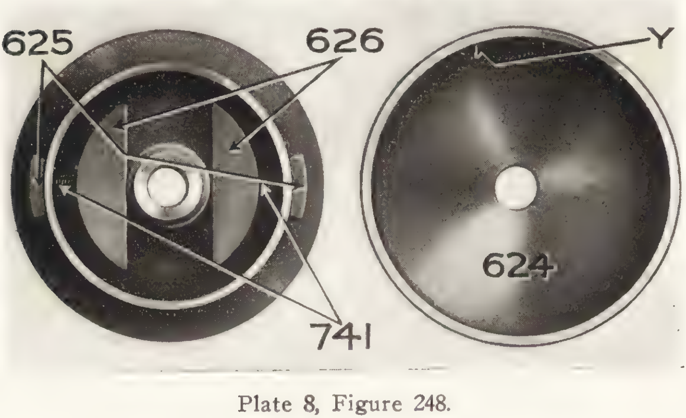


Plate 8, Figure 248.

parts, as shown in P. 1 and 2, are assembled, with the exception of the lever R 52, Fig. 3, but the control is not attached to the stand. To attach the control, place same in position, as shown in P. 1 and 2, with the motor toward the rear end of the projector, and fasten in place by means of bolts R 5 (four of them), P. 1 and 2. Be sure that the contacts between the casting and the control are clean, and set up bolts R 5, *tight*. This instruction holds good with both the old style 6A non-adjustable and the new style 6B adjustable stand.

It is then necessary to attach the lever control, P. 3. If it is the old style 6A non-adjustable stand this lever and its casting is attached by means of bolts R 47 and R 48, P. 3. If it is the new style 6B adjustable stand, then a special bracket, the bottom of which is shown at X, P. 1, is sent. This bracket is attached to the casting by means of two heavy machine screws, one of which is shown at Z, P. 1. Having attached the control lever, all that is necessary to complete the installation is the connecting of lever R 52, P. 1, with the end of the control lever at R 42, P. 3, and with the bell link R 53, P. 1.

Note: All parts except very small screws have the regular stock number either stamped or cast right into the part—a very excellent arrangement. Parts may be ordered by using these numbers. All machine stands are drilled to receive the speed control, so that you can order it at any time, and install under the foregoing instructions.

Instruction No. 1.—The friction material, R 15, P. 2, is leather. Should it at any time develop flat spots, or become out of round or eccentric in form, it may be trued by placing the point of a new 10-inch or 12-inch coarse file on rod R 39 (using the rod merely as a rest) and bearing lightly on the top of the friction material, with the motor running. *In doing this, be very careful to hold the point of the file perfectly flat on the rod,* since if you hold it at an angle you will get the face of the leather ground off on a slant, and it will then not fit the disc wheel squarely.

Instruction No. 2.—New friction material may be ordered from the Nicholas Power Company at any time. The old material may be removed by loosening the set screws in hub R 16, P. 2, and in set collar R 21 and in R 24, P. 2, Having done this, R 25, P. 2, may be pulled out to the right, thus releasing the friction wheel. You can then take out the old friction material by removing the screws in the face of R 16, P. 2. The process of reassembling is the reversal of

the process of disassembling, but these parts run at high speed, therefore be sure and set up all the screws *tight*.

Instruction No. 3.—Caution: *Never leave the controlling lever down when the projector is standing still. Always pull the lever clear up, so as to disengage friction wheel R 15, P. 2, from driving disc R 13, P. 2. Failure to attend to this matter will probably result in flat spots on the friction material.* In nine cases out of ten where flat spots develop it is caused by failure to heed this warning.

Instruction No. 4.—Tension.—It is of course necessary that there be sufficient tension or friction between friction material

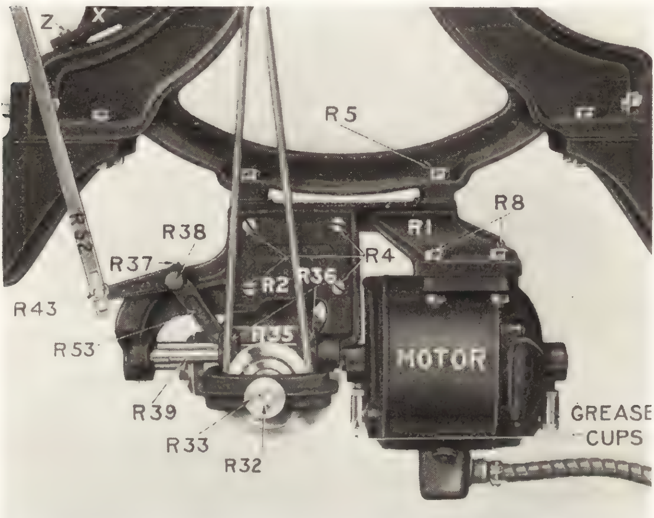


Plate 1, Figure 249.

R 15 and driving disc R 13, P. 2, to pull the projection mechanism, but anything more than sufficient to accomplish this purpose will merely result in undue wear of the friction disc, friction material and unnecessary consumption of power in the motor. The tension or amount of friction between friction material R 15 and friction disc R 13, P. 2, is regulated by thumb screw R 32, P. 1. Proceed as follows:

Loosen lock nut R 33, P. 1, and loosen up on tension screw R 32, P. 1, until friction material R 15 and disc R 32 are out

of contact. Now, start your motor running and having set the controlling lever down so that the friction driving wheel is pretty well in on the friction disc, slowly tighten up on tension screw R 32, P. 1, until the projection mechanism attains full speed and you are satisfied there is no slippage between the friction disc and driving wheel. Having done this, your tension will be just right, provided, of course, you have followed the instructions carefully, and have set up

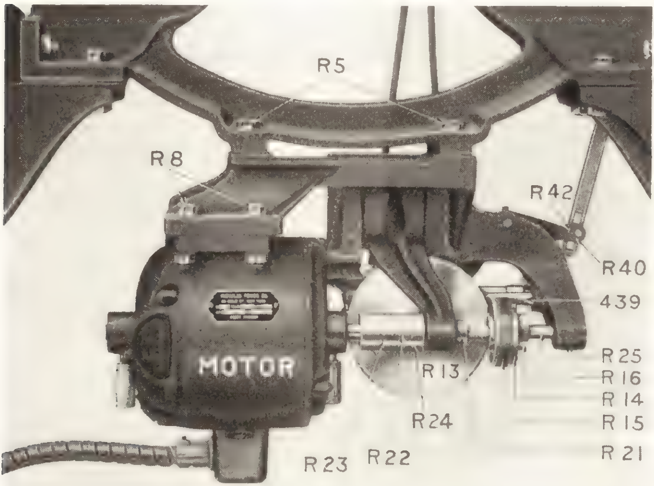


Plate 2, Figure 250.

screw R 32 only sufficient to bring the projector up to full speed, this being done, of course, with the film in the machine, or in other words, under actual operating conditions. Having got the adjustment just right, don't forget to tighten up lock nut R 33, or else the adjustment is likely to work loose.

Instruction No. 5.—Grease cups (two of them), P. 1, should be kept filled with some good lubricating grease (not oil but grease), which may be obtained from any automobile supply store. The commutator of the motor can be got at by opening the two latticed cast-iron doors on the end of the motor.

Instruction No. 6.—The motor may be disengaged merely by removing bolts R 6, P. 1 and 2, and disconnecting its cable. When putting the motor back be sure and line the shaft of the motor correctly with the friction driving shaft R 25. If you don't do this, there will be trouble and probably more or less noise. In fact, should the device develop noise at any time, and you find that the friction wheel material is true, then the next thing to look at is the alignment of these two shafts; it being possible that bolts R 8 have worked loose and let the motor get out of alignment with driving shaft R 25.

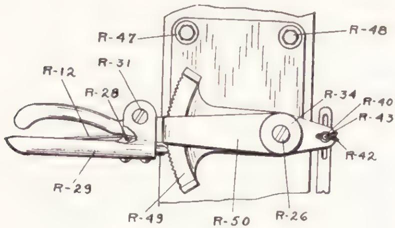


Plate 3, Figure 251.

Instruction No. 7. **No Oil.**—With the exception of the motor bearings, none of the other bearings of this device requires any lubrication whatever, this by reason of the fact that the bushings are all of material which requires no lubrication.

PARTS FOR POWERS SIX B AND MOTOR DRIVE

Order parts by number. Column to left indicates plate upon which they appear.

Plate	No.	
1	601	Main frame casting.
3	602	Top frame casting.
7	603	Frame carriage.
6	604	Top frame supporting rods (2).
3 & 5	605	Stero bracket holder with thumb screw.
—	606	Stero bracket holder with thumb screw
—	607	Stero collar bracket.
—	608	Stero lens rod.
2	609	Small top roller.
7	610	Small top roller spindle.
2	611	Set collar for small top roller.
2	612	Upper roller bracket.
5	613	Large upper roller.
7	614	Large upper roller spindle.
2	615	Upper roller bracket spring.

Plate	No.	
7	616	Set collar for large top roller.
7	617	Upper sprocket.
7	618	Upper sprocket spindle
1 & 4	619	Upper sprocket feed gear (large).
1 & 4	620	Upper sprocket feed gear (small).
4	621	Pinion for auto. shutter spindle.
2 & 3	622	Spindle for auto. shutter.
3 & 7	623	Friction case cover for auto. shutter.
2	624	Friction case for auto. shutter.
—	625	Friction shoe with spring for auto. shutter
—	626	Weight for auto. shutter.
7	627	Lever for auto. shutter.

Plate	No.	
7	628	Link for auto. shutter.
3	629	Counter weight for auto. shutter.
4	630	Crank shaft driving gear.
4 & 7	631	Crank shaft.
7	632	Crank shaft with handle complete
4	633	Small gear meshing in driving gear.
4	634	Large gear for revolving shutter.
4	635	Small gear for revolving shutter.
4	636	Spindle for front shutter.
4	637	Bracket for revolving shutter.
4	638	Set collars for front shutter spindle (2).
—	639	Stud with screw for front shutter bracket.
4	640	Large idler gear.
4	641	Idler gear spindle (large).
5	642	Large idler gear spindle set collar.
—	643	Take-up feed pinion.
—	644	Take-up feed pulley.
—	645	Take-up feed spindle
2	646	Take-up feed sprockets
4	647	Framing device clamp.
4	648	Framing lever socket.
4	649	Framing lever socket link.
1	650	Framing lever.
—	651	Framing device screw.
4	652	Framing device wing nut.
1	653	Take-up roller bracket.
—	654	
1	655	Take-up roller spindle.
4	656	Set collar for small spindle.
2 & 4	657	Take-up roller.
2	658	Take-up roller bracket spring.
2	659	Intermittent roller bracket
2	660	Intermittent roller.
—	661	Intermittent roller bracket spindles.
—	662	Intermittent set collar for shaft.
—	663	Intermittent spring.
—	664	Contact screws for gauge.
2	665	Intermittent spindles.
2	666	Pin cross (with spindle).
2	667	Intermittent sprocket.
-	668	Gate spring support.
1	669	Apron complete.
2	670	Intermittent bushing (large).
1	671	Intermittent bushing (small).
5 & 3	672	Flywheel
4	673	Oil cup int. movement.
4	674	Cover for int. movement.
—	675	Cam for int. movement.
2	676	Cam shaft.
7 & 1	677	Flywheel pinion.
7	678	Toggle joint idler gear.
7	679	Toggle joint idler gear spindle.
3	680	Driving gear for idler.
3	681	Driving gear spindle.
7	682	Connecting link.
7 & 3	683	Small horizontal lever.
8	684	Large guide casting.
7	685	Small casting.
7	686	Studs for horizontal lever.
2	687	Aperture plate.
5 & 6	688	Front plate.
1	689	Gate.
1	690	Hinge for gate.
7	691	Guide rollers.
7	692	Guide rollers, bushings, spring and spindle.
1	693	Latch for door
—	694	Tension shoe.
—	695	Gate hinge pin.
1	696	Cooling plate.
1	697	Flap for auto. shutter.
1	698	Rock shaft auto. shutter.
2	699	Carriage guide rods.
6	700	Outside revolving shutter blade.
6	701	Outside revolving shutter bushing (large).
6	702	Outside revolving shutter bushing (small).
6	703	Outside revolving shutter flange complete.
5	704	Lens ring screws.
1	705	Upper film shield.
7	706	Lower film shield.
—	707	Spindles for lower film shield.
—	708	Lower film shield bracket.
3	709	Flywheel spindle screw.
—	710	Upper roller bracket screws and nut.

Plate	No.	
2	711	Screws for No. 658.
—	712	
2	713	Screws for aperture plate.
5	714	Lens ring.
—	715	Screws holding intermittent roller bracket.
—	716	Lower film shield spring.
—	717	Screws holding take-up bracket spring.
2	718	Screws holding governor cover to shaft.
1 & 2	719	Screws adjust. intermittent shaft.
1	720	Screw stud holding upper roller bracket.
2	721	Screw holding upper sprocket roller spindle.
2	722	Gate latch screw and nut.
1 & 2	723	Screw holding right hand bushing for intermittent (No. 671).
4	724	Screw to adjust lower sprocket rollers with nut.
—	725	Screw holding take-up roller bracket.
—	726	Collars for lower bracket spindle.
3	727	Screws holding top frame casting support rods.
7	728	Screws holding horizontal lever.
3	729	Spring for gate roller guide.
4	730	Screws holding framing device clamps.
6	731	Stamp on wide wing of shutter.
4	732	Upper screw holding revolving shutter bracket.
5	733	Lower screw holding No. 637.
1	734	Screw for adjusting tension shoes.
6	735	Pin through No. 631.
5	736	Oil hole back of No. 637.
5	737	Magazine thumb screws.
2 & 1	738	Set screws for sprocket.
6	739	Screws in outer shutter hub.
6	740	Screws holding No. 700 to shaft.

Plate	No.	
--	741	Springs for auto governor friction shoe.
7	742	Set screw for No. 679.
2	743	Screw holding No. 670.
7	744	Set screws to tighten No. 682.
7	745	Screws holding No. 685 against No. 682.
7	746	Slots in No. 677.
7	747	Pins to engage in No. 746.
7	748	Washer between No. 677 and No 603.
4	749	Oil casing cover screws.
—	750	Screws holding apron No. 669.
—	751	
—	752	Screw top end of No. 628.
-	753	Screw holding upper fire shield.
5	754	Screw holding No. 688.
—	755	Screw holding tension shoes.
—	756	
—	757	Hinge screws.
--	758	Screws holding lower fire shield bracket.
—	759	Screws holding roller idler spindle to bracket.
—	760	Screws holding top end of No 628.
4	761	Loop setter cam.
4	762	Loop setter gear.
—	763	Cam pin for fork.
4	764	Loop setter pulley shaft.
4	765	Loop setter pulley.
4	766	Loop setter clutch.
4	767	Loop setter bearing
4	768	Loop setter fork.
3	769	Loop setter roller.
--	770	Loop setter roller washer.
4	771	Loop setter clutch pin (short).
—	772	Loop setter clutch pin (long).
—	773	Loop setter arm spindle
4	774	Loop setter pulley pin.
—	775	Loop setter stud for bearing.
—	776	Loop setter clutch pin for fork.
4	777	Loop setter pulley washer.
—	778	Loop setter set screw for roller spindle.

Plate	No.		Plate	No.	
—	779	Loop setter set screw for cam.	2	787	Set screw and nut for gate stop.
—	780	Loop setter set screw No. 767 to No. 601.	2	788	Screws for intermittent spring.
—	781	Loop setter set screw and nut for No. 758.	2	789	Screws to fasten angle on No. 692.
—	782	Screws for fastening No 690 to No. 601.	2	790	Screws to fasten No. 696 to No. 689.
—	783	Set collar for intermittent shaft.	—	791	
			—	792	
1	784	Screws to fasten No. 705 to No. 689.	4	793	Screw for take-up roller spindle.
7	785	Screws to fasten No. 628 to No. 601.	4	794	Screw for cover No. 674 to No. 603 (carriage).
7	786	Set screws for handle No. 632.	2	795	Pins for No. 631.
			3	796	Screws to hold No. 641

Instructions for Simplex Mechanism

Note: The numbers refer to parts and plates, thus: W-128-B, P. 4, means that part W-128-B, which by reference to the list of parts, we find to be the fly wheel of the intermittent movement, will be found on Plate 4.

No. 1. To Remove the Film Trap Door, E 4, P. 5, lift it straight upward, unhooking the door from pins. The door will disengage when raised. Should it stick tap upward lightly on bottom of door.

No. 2. To Remove Intermittent.—To take out whole intermittent movement, remove screw, S-209-G, P. 3, pull off gear, G-112-G, P. 3. Push in on film trap screw, S-134-E, P. 2, which opens door. Next remove or pull back the lower right hand back section of machine—the door with the curved top immediately below the aperture. Next loosen screws, S-157-B, P. 2 and 4, and push back locks, L-116-B, P. 4, so that they no longer engage ring, R-133-A, P. 1, on framing cam, C-100-A, P. 1 and 4. Loosen collar, C-192-G, P. 5, grasp fly wheel, W-128-B, P. 3, with right hand, and pull straight outward, at the same time pulling out gear, G-133-G, P. 3, with the left hand. You thus remove the entire intermittent casing, fly wheel and intermittent sprocket. In replacing same, reverse the process of removal step by step, first reading Instruction No. 8 carefully.

No. 3. Adjusting Star and Cam (See last part of General Instruction No. 5) is done as follows: Loosen two screws, S-125-B, P. 4. Grasp hexagon on B-132-B, P. 4, with the wrench supplied with each machine, or with a plier, and turn same slightly either way until the lost motion in the sprocket is almost taken up, leaving just enough play so that

you can barely feel the sprocket move when you try to rock it circumferentially. Tighten screws (two of them), S-125-B, P. 4, when you are finished.

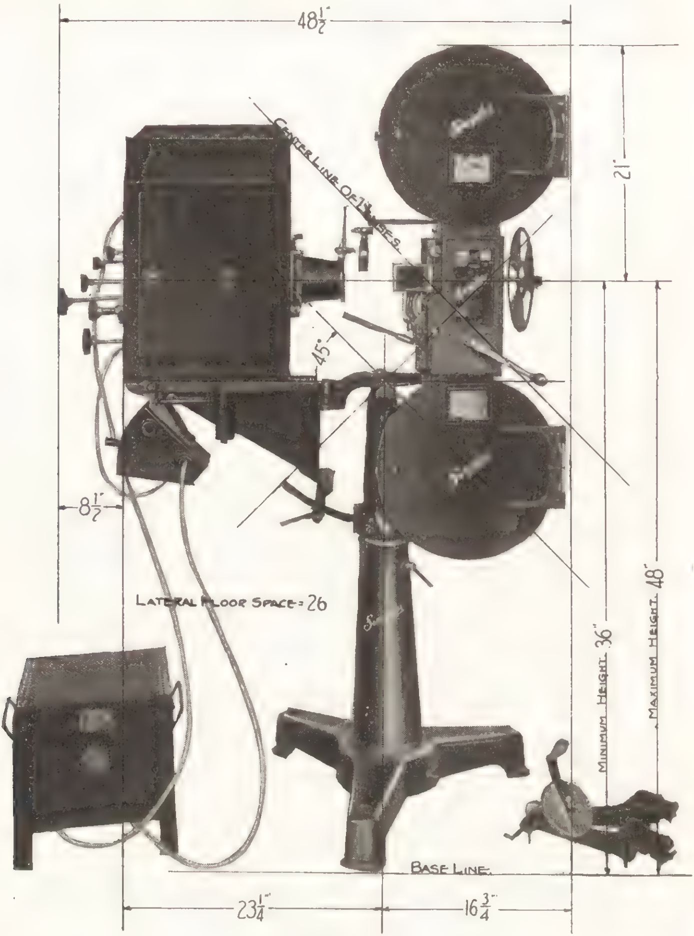


Figure 252.

No. 4. Removing and Replacing Intermittent Sprocket.— (I do not recommend it. See last part General Instruction

No. 5.) When the sprocket teeth become undercut, that is to say, having a groove worn in the surface presented to the film, the sprocket should be removed and a new one installed, (*it is a good plan to have an eccentric bushing,* B-132-B, P. 4 and 5, *star* and *spindle,* S-299-B, P. 5, and *intermittent sprocket,* W-131-B, P. 1, *already assembled, ready to place in the machine when required*) this being done as follows: Loosen the two screws, S-125-B, P. 4, and, grasping intermittent sprocket, pull straight out, thus removing bushing, star, spindle and sprocket from the casing. Next carefully remove sprocket from spindle. To do this first remove taper pin which holds

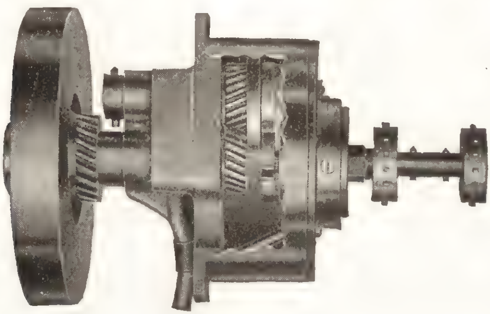


Figure 253.

Showing the relation of the parts of the intermittent movement, a portion of the casing being cut away to show you the parts in place.

the sprocket to the shaft, and with a cloth in the left hand grasp star and bushing firmly, while with the right hand you pull the sprocket from its spindle with a twisting motion. Should the sprocket stick you may lay the edges on a vise and with a brass or copper punch gently drive the spindle out. Be very careful, if the sprocket is good, that you do not ruin it in the process, as its rim is thin and easily battered or bent. In installing the new sprocket be very sure that the large diameter of the pinholes in shaft and sprocket are together. To replace parts in the machine, first wipe the bushing and its bearing parts perfectly clean and lubricate with good clean oil. Push the bushing into its bearings until the star is against the cam; turn the fly wheel slowly, at the same time pushing in on the sprocket until pin, P-177-B, P. 5, on cam, C-178-B, P. 5, engages with star slot, when bushing may be pushed home; after which adjust

star to cam as per Instruction No. 3 and tighten up the two screws, S-125-B, P. 4. See Instructions Nos. 10 and 11.

No. 5. **Cleaning Sprockets**—See General Instruction No. 3.

No. 6. **End Play of Intermittent.**—See General Instruction No. **7.**

No. 7. **To Remove Intermittent Casing Cover,** C-148-B, P. 4 and 5, first follow instruction Nos. 2 and 4, next in-

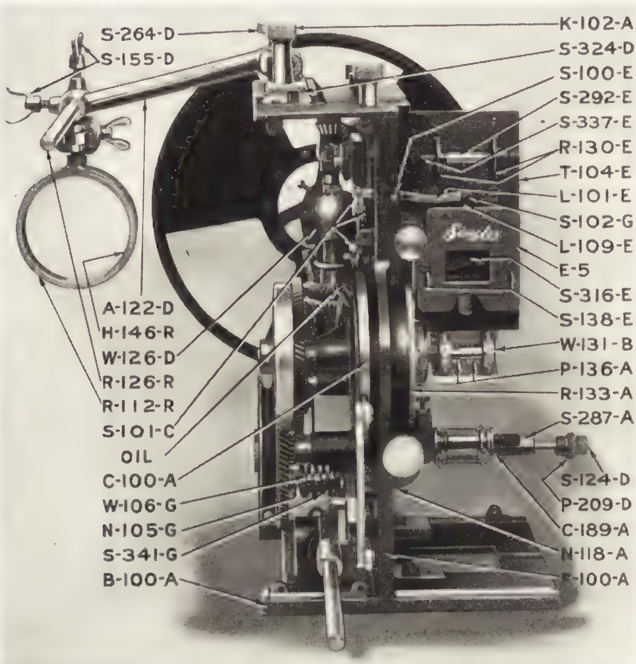


Plate 1, Figure 254.

sert spanner wrench in hole on C-148-B, P. 4, and unscrew the cover from casing. The screw on this cover is an ordinary right hand thread. See Instructions Nos. 10 and 11.

No. 8. **To Remove Cam,** C-178-B, P. 5, first follow Instructions Nos. 2, 4 and 7; then remove taper pin holding collar, C-134-B, P. 4, and pull collar off. The cam and its

spindle may then be pulled out. See Instructions No. 10 and 11.

No. 9. **To Remove Flywheel Shaft,** S-286-B, P. 3, first follow Instructions Nos. 2, 4, 7 and 8; then drive out taper pin, P-123-B, P. 3, pull off flywheel and shaft will slip out. See Instructions Nos. 10 and 11.

No. 10. **Replacing Bushing,** B-132-B, P. 4 and 5, and Intermittent Casing, C-107-B, P. 4 and 5. This is a very simple operation. It is, however, of great importance that it be rightly done. Both the casing and bushing fit in their bearings very closely. It is therefore necessary that they, as well as their bearings, be cleaned perfectly and lubricated with a good, clean oil. Having done this, push the casing or bushing carefully into place, turning or shaking it slightly if it sticks. Never under any circumstances attempt to drive the parts into place. You will simply ruin both bearings and casings, or bushings, if you do.

No. 11. **To Replace Intermittent Casing,** C-107-B, P. 4 and 5, in the machine, first follow Instruction No. 10; then hold flywheel, W-128-B, P. 3 and 4, in right hand, and gear, G-133-G, P. 3 and 4, in left hand with gears meshed together; insert shaft and casing, C-107-B, P. 4 and 5, into bearings and push both casing and gear into place together, having the rim of casing in such position that locating pin, P-125-A, P. 4, enters hole in casing rim. The rest of the operation is simply a reversal of Instruction No. 2. See that the clutch, C-126-A, P. 4, locks with its mate properly when gear, G-112-G, P. 3 and 4, is pushed into place.

No. 12. **To Remove Gear,** G-143-G, P. 4, or the complete Governor or Vertical Shaft, S-443-G, P. 4, loosen set screw in hub of gear G-143-G, P. 4, next remove set screw in governor ling holder and, grasping gear G-138-G, P. 4, pull upward. Vertical shaft, S-443-G, P. 4, will come out, thus releasing the other parts.

No. 13. **To Remove Spiral Gear,** G-116-G, P. 4, first follow Instruction No. 12; then remove set screw holding collar, C-193-G, P. 5, and pull shaft out to the right.

No. 14. **To Remove Spiral Gear,** G-117-G, P. 4, remove set screw from end of gear. Spindle will slip out to the left, thus releasing gear.

No. 15. **To Remove Shutter Gear Bracket,** B-122-G, P. 2 and 3, first follow Instruction No. 14; then remove the two screws, and bracket will come off.

No. 16. **To Remove Shaft of Outside Revolving Shutter,**

S-447-G, P. 2, remove the set screw from gear, G-117-G, P. 4, and shaft may be pulled out.

No. 17. To Remove Shutter Blade take out the ten screws, S-142-D, P. 2, in spider, S-325-D, P. 2.

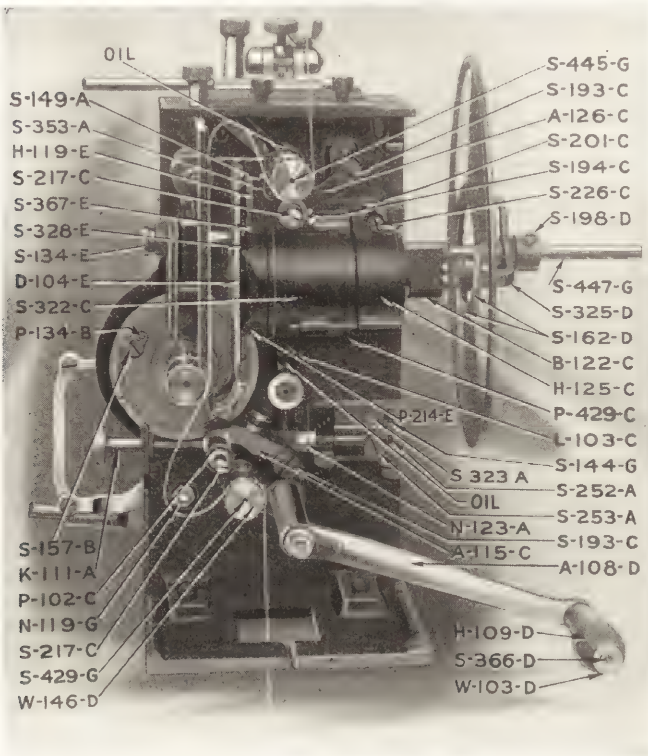


Plate 2, Figure 255.

No. 18. To Remove Shutter Adjusting Slide Block, S-323-A, P. 2, remove pin near outer edge of lower track or slide, and turn the knob, K-111-A, P. 2, to the left until sliding block, S-323-A, P. 2, is released.

No. 19. To Remove Shaft or Screw, S-252-A, P. 2, loosen

lock nuts, 123-A, P. 2, turn knob to left until sliding block, S-323-A, P. 2, is released. Remove the lock nuts and the shaft may be pulled out.

No. 20. To Remove Focusing Slide, which carries lens holder H-125-C, P. 2, remove the screw which holds same to frame, F-100-A, P. 1, and the slide will come out. On top there will be found a small gib which provides tension. Be sure to replace this gib when putting the parts together again.

No. 21. To Remove Framing Cam, C-100-A, P. 1 and 4, take out upper screw, S-223-G, P. 3. Remove door, as per Instruction No. 1. Remove screws, S-133-C, P. 4, which releases the film trap. Loosen screws, S-143-A, P. 5, unscrew ring and the cam may then be pulled out to the left. The framing cam, C-100-A, P. 1 and 4, is a large ring bearing in which the intermittent casing, C-107-B, P. 4 and 5, rests. To replace same, just reverse the process, screwing up ring until cam has no end play, after which set up screw, S-143-A, P. 5, tight, as this is the screw which locks ring in place.

No. 22. To Remove Automatic Fire Shutter Lift Lever, first remove screw in link. Next remove film trap, as per Instruction No. 1, and take out pivot screw.

No. 23. To Remove Governor Lift Lever, L-105-G, P. 4, remove lower screw in link, and screws, S-150-G, P. 4.

No. 24. To Remove Framing Slide Lever, L-104-G, P. 3, first remove gears, G-112-G, P. 3 and 4, and G-133-G, P. 3 and 4, and intermittent casing, as per Instruction No. 2. Loosen screw, S-145-G, P. 3, which allows you to pull out lever, L-104-G, P. 3, carrying spring, S-330-G, P. 3, with it. This also releases framing slide arm, A-110-G, P. 4, carrying roller, R-128-G, P. 4, which may be pulled out after lever, L-104-G, P. 3, has been removed.

No. 25. Spring, S-330-G, P. 3. This spring is for the purpose of holding roller, R-128-G, P. 4, against the framing cam, C-100-A, P. 4. It also holds lost motion out of parts between lever and framing cam. To remove the spring take out screw, S-145-G, P. 3, which releases the spring. To replace, put it on its stud in same position as it was, then bend the free end around to the right until it enters slot in end of stud. Place washer on and replace screw, S-145-G, P. 3, setting it up tight.

No. 26. Framing Handle Tension Spring, S-341-G, P. 1. This spring causes framing handle, or lever, H-105-C, P. 3, to work hard or easy, according to how it is adjusted. If lever,

H-105-G, P. 3, works too hard, this spring has too much tension: if too easy there is not enough. To change the tension, first remove screw, S-209-G, P. 3, and pull off gear G-112-G, P. 3. Loosen outer one of nuts and tighten or

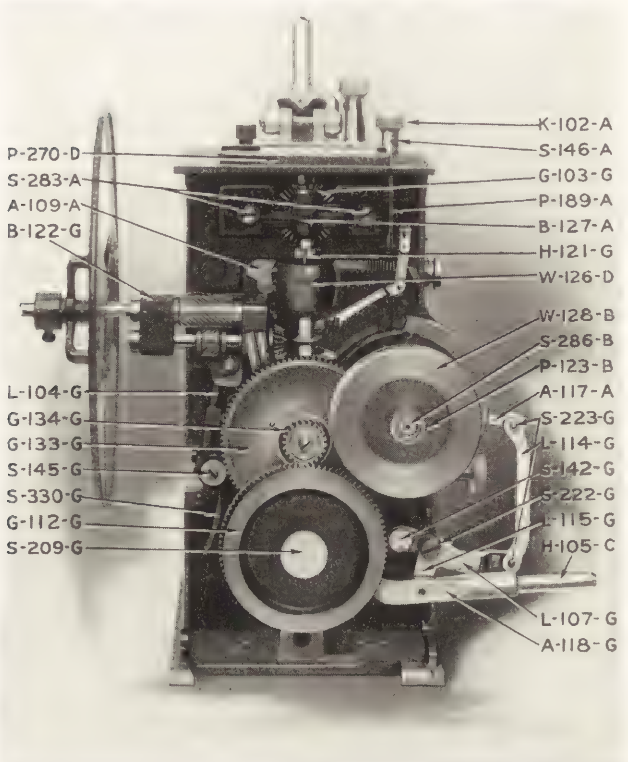


Plate 3, Figure 256.

loosen inside nut until the lever works to suit you, after which lock the nuts tightly together again.

No. 27. Film Trap Door Holder, H-119-E, P. 2 and 5, is held in place by film trap door holding stud, S-367-E, P. 2 and 5, which runs through and is held by a screw on the

outside which also retains a thimble, inside of which is a coil spring, which holds the door against film trap. All these parts may be readily removed as follows: Place a piece of cloth or paper, between the jaws of a pair of pliers to prevent marring the metal, and unscrew, thus releasing the spring and stud, S-367-E, P. 2 and 5. The metal thimble on screw, S-134-E, P. 2, is merely to protect and hold the coil in proper position. If it is desired to remove the door holder and stud also you must take off film trap. (See Instruction No. 1.)

No. 28. Film Trap Shoes, S-309-E, P. 5, may in time wear. (See General Instructions Nos. 9 and 10.) They may be removed by taking out the three screws in front of the film trap which holds them in place. Should the screws project through when new shoes are installed, they must be carefully dressed down flush with surface of the film trap, using a fine file, this also applying to film trap gate shoes.

No. 29. Intermittent Sprocket Tension Shoes attached to holder, H-118-E, P. 5, are made of tool steel. They hold the film in contact with intermittent sprocket, W-131-B, P. 1; their adjustment is therefore important. They must be set so that their curved portion just barely touches the sprocket rim. It must, however, be observed that the inside half of each shoe is offset so that it is away from the sprocket slightly when the outer edge touches. Set by the outer half only. Look at the shoes occasionally and see that they are in proper adjustment.

No. 30. Lens Holder, H-125-C, P. 2, may be shifted forward or backward on sliding block, by loosening clamp screw. In installing new lens, place sliding block in center of its travel by means of focusing knob, K-102-A, P. 3. Place lens in adapter ring. These rings are made to fit various sizes of lenses. Loosen clamp screw, and slide lens back and forth until edges of aperture appear in sharp focus on the screen. Tighten clamp screw and complete focusing by means of knob, K-102-A, P. 3. Tube projection lenses only may be used on the Simplex machine. It is therefore unnecessary to purchase a lens jacket.

No. 31. Upper and Lower Sprocket Roller, P-102-C, P. 2, (See General Instruction No. 12), must be carefully adjusted with relation to the sprockets. The upper roller is adjusted by means of screw, S-194-C, P. 2, That of the lower idler is adjusted by a similar screw, S-194-C, P. 2, These rollers must be kept set away from the sprockets by about

twice the thickness of a film. If set too close it has a tendency to cause the film to run off the sprockets. If too far away it may cause the sprocket holes to climb, that is, the film may slip over. In either event the effect is to lose the loop. It will be seen that these adjustments are of the

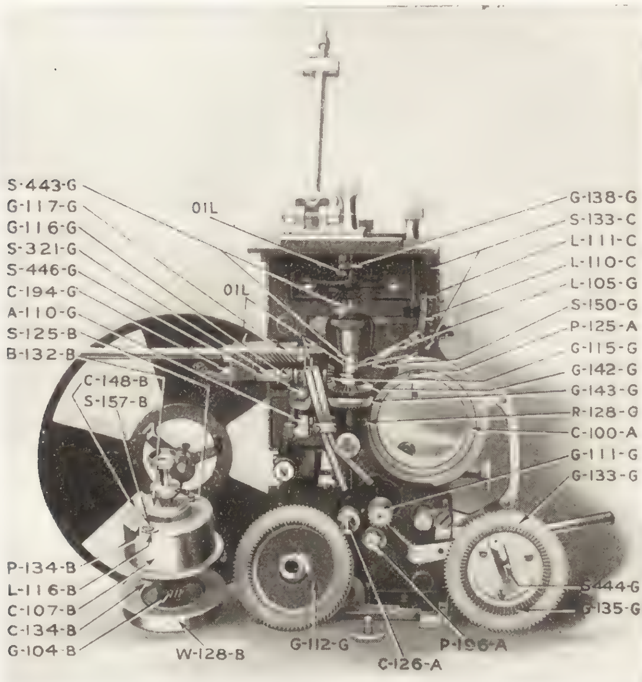


Plate 4, Figure 257.

utmost importance. After making adjustment be sure to set up the adjusting screw lock nuts tightly.

No. 32. Roller Arm Tension Springs.—Upper sprocket roller arm, A-126-C, P. 2, is held against sprocket by means of a spring clamped under screw, S-149-A, P. 2. To remove this spring, take off film trap, as per Instruction No. 1. The lower roller arm spring, S-340-A, P. 5, is held by two screws

which may be removed through the opening in base, B-100-A, P. 1, of the machine.

No. 33. Aperture Size.—The Simplex aperture opening is exactly .9062 inch wide by .6796 inch high, the height being three-quarters of the width. These dimensions may be used in figuring lenses for this machine.

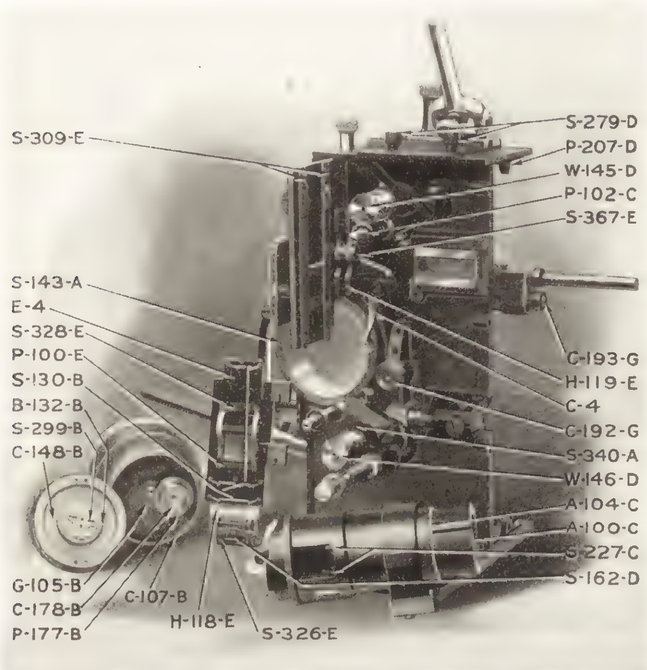


Plate 5, Figure 258.

No. 34. Oil.—(See General Instruction No. 1.) Also the Precision Machine Company sells Simplex Oil at $2 a gallon, $1 a half gallon.

No 35. Washing Gears and Bearings.—Simplex gears and bearings are well protected from dust and dirt. Still, it is not a bad plan to wash them thoroughly with kerosene or benzine once each week. Use an ordinary oil can filled with

kerosene or benzine and flood the gears and bearings thoroughly while turning the crank. Use rags under the gears to catch the dirty oil as it runs off. See third from last paragraph General Instruction No. 1.

No. 36. Setting the Shutter.—(See General Instruction No. 18.) The revolving shutter may be set while the machine is running by turning knob, K-111-A, P. 2. If white streaks show at top or bottom of letters in titles or there are flashes of white up and down from any white object in film it is evident that the shutter is out of adjustment. Turn knob, K-111-A, P. 2, one way or the other until the ghost disappears.

No. 37. Focusing Lens.—The picture on the screen is readily focused by turning knob, K-102-A, P. 3, which moves the objective lens closer to or further from the film, according to the way it is turned.

No. 38. Clean Sprockets. (See General Instruction No. 3.)

No. 39. Tension Pad, P-100-E, P. 5, holds the film flat and stationary over the aperture during exposure. Tension for pad, P-100-E, P. 5, is provided by spring, S-328-E, P. 2 and 5. The tension is constant and can only be varied by bending the springs. (See General Instruction Nos. 9 and 10.)

No. 40. Stereopticon Lens.—The stereo lens will be placed in its mount and clamped there by a ring, R-112-R, P. 1. To adjust lens loosen wingnuts, S-155-D, P. 1, and slide the lens and mount either forward or backward on rod, R-126-R, P. 1, until picture is in approximate focus on screen. Tighten wingnuts, S-155-D, P. 1, again and complete focusing with knob on top of mechanism, K-102-A, P. 1. The stereo lens may be raised or lowered by means of screw, S-264-D, P. 1, on stero arm, A-122-D, P. 1, thus centering the picture on the screen.

No. 41. Oil Holes will be found, as indicated on the various plates.

No. 42. Worn Aperture Plate.—See General Instruction No. 11.

SIMPLEX SPEED CONTROLLER

The speed controller of the Simplex projector is simple, positive in its action, and very flexible in the matter of speed control. In fact, within the limits of minimum and maximum it is possible instantly to attain absolutely any desired speed of the projection mechanism within practical limits of projection.

In Fig. 259 we have a top view and in Fig. 260 a side view of the Simplex Controller; X-7 and D-110-X are two

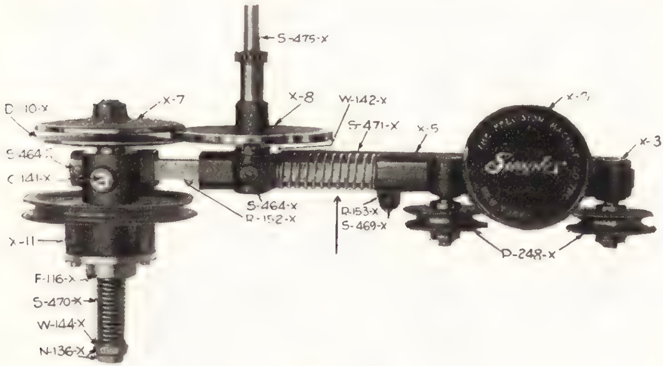


Figure 259.

friction discs held normally face to face by spring S-470-X, but really held separated by disc wheel X-8, which is carried by shaft S-475-X, which engages with and drives the projection mechanism. The operation is essentially as follows: R-152-X is a steel bar half inch square, which is rigidly attached to the casting carrying wheel X-11, and disc wheels X-7, and D-110-X. All these parts are attached rigidly to bar R-152-X, and move therewith, as does also casting X-3 at the other end of the bar carrying the end belt idler pulley P-248-X.

On the other hand casting F-115-X, Fig. 260, carries friction disc wheel X-8, adjusting wheel X-9 and the inner idler belt pulley P-248-X. This casting carrying the parts is moved along on bar R-152-X by means of adjusting wheel X-9, and when it is moved friction wheel X-8 is thrust farther in between friction discs X-7 and D-110-X, or pulled further out, according to the direction in which adjusting wheel X-9 is rotated, and the farther in wheel X-8 is the slower will the moving picture mechanism run, or the farther out it is the faster it will run, X-11 being the motor belt pulley.

The amount of friction between the disc wheels may be regulated by means of nuts N-136-X. The farther in they are screwed the greater will be the amount of friction, or the more they are loosened up the less the friction. The friction

should never be more than just sufficient to carry the load without slipping. Anything in excess of this means unnecessary wear to the parts.

Caution: Operators must see to it that there is no oil on the friction surfaces of X-8, X-7 and D-110-X. These surfaces must be kept perfectly dry.

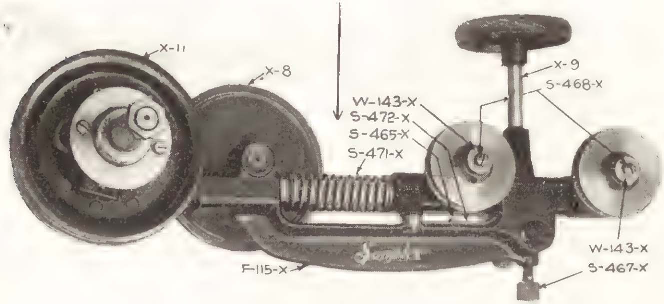


Figure 260.

C-141-X is an oilhole closed by a steel ball. Press on the ball with the nose of the oil can and the oil will run in. Spring S-471-X merely governs the tension of the driving belt.

SIMPLEX MECHANISM PARTS

Numbers Are Manufacturers' Stock Numbers. You May Use These Numbers for Ordering Parts.

Note.—The letter following the number denotes the portion of the mechanism to which the part belongs, thus: A, Center Frame Assembly; B, Intermittent Case Assembly; C, Mechanism Assembly; D, Outside Mechanism Assembly; E, Film Trap Assembly; F, G, Inside Mechanism. Hence if you are looking for a part belonging to the film trap assembly, look at the part numbers ending in E.

Plate No.	Stock No.	Description
3	A-109-A	Focusing rack arm.
3	A-117-A	Picture framing arm.
1	B-100-A	Base.
3	B-127-A	Vertical shaft bracket.
1	C-100-A	Framing cam.
4	C-126-A	Main driving gear clutch.
1	C-189-A	Handle shaft driving collar.
1	F-100-A	Centre frame.
1	K-102-A	Focusing pinion knob.
2	K-111-A	Shutter adjusting screw knob.

Plate No.	Stock No.	Description
1	N-118-A	Picture framing handle pivot nut.
2	N-123-A	Shutter adjusting screw lock nut.
4	P-125-A	Framing cam locating pin.
1	P-136-A	Inter-sprocket wheel taper pin.
3	P-189-A	Focusing pinion.
4	P-196-A	Picture framing handle pivot.
1	R-133-A	Framing cam adjusting ring.
5	S-143-A	Framing cam adjusting ring screw.
3	S-146-A	Focusing knob set screw.
2	S-149-A	Upper sprocket arm spring screw.
2	S-252-A	Shutter adjusting screw.
2	S-253-A	Shutter adjusting slide set screw.
3	S-283-A	Vertical shaft bracket screw.
1	S-287-A	Handle shaft.
2	S-323-A	Shutter adjusting slide.
5	S-340-A	Lower sprocket roller arm spring.
2	S-353-A	Upper sprocket roller arm spring.
4	B-132-B	Eccentric bushing.
4	C-107-B	Intermittent case.
4	C-134-B	Star wheel cam collar.
5	C-148-B	Intermittent case cover.
5	C-178-B	Star wheel cam.
4	G-104-B	Fly wheel gear.
5	G-105-B	Fly wheel shaft gear.
4	L-116-B	Intermittent case cover lock.
3	P-123-B	Fly wheel taper pin.
2	P-134-B	Intermittent case cover dowel pins.
5	P-177-B	Star wheel cam pin.
4	S-125-B	Intermittent case eccentric bush. sc.
5	S-130-B	Film guide holder screw.
2	S-157-B	Intermittent case cover lock screw.
3	S-286-B	Fly wheel shaft.
5	S-299-B	Star wheel and shaft.
3	W-128-B	Fly wheel.
1	W-131-B	Intermittent sprocket wheel.
5	A-100-C	Proj. lens holder adapter, inside.
5	A-104-C	Proj. lens holder adapter, outside.
2	A-115-C	Lower sprocket roller arm.
2	A-126-C	Upper sprocket roller arm.
5	C-4	Film trap lever, complete.
3	H-105-C	Picture framing handle.
2	H-125-C	Proj. lens holder.
2	L-103-C	Film trap door trip lever.
4	L-110-C	Governor lift lever link.
4	L-111-C	Governor lift lever connecting link.
5	P-102-C	Pad roller.
1	S-101-C	Auto fire shutter hinge screw.
4	S-133-C	Film trap screw.
2	S-193-C	U. & L. sprocket roller arm screw.
2	S-194-C	Lower sprocket roller arm screw.
2	S-201-C	Proj. lens holder jacket screw.
2	S-217-C	Pad roller screw.
2	S-226-C	Proj. lens holder clamp screw.
5	S-227-C	Proj. lens holder slide stop screw.
2	S-322-C	Proj. lens holder slide
2	A-108-D	Driving arm.
1	A-122-D	Stereo slide arm.
2	H-109-D	Driving arm handle.
5	P-207-D	Top plate.
1	P-209-D	Driving arm retaining plug.
1	S-124-D	Driving arm retaining screw.
1	S-155-D	Stereo universal clamp wing screw.
2	S-162-D	Stereo slide top screw.
2	S-198-D	Shutter spider clamp collar screw.
1	S-264-D	Stereo lens adjusting screw.
5	S-279-D	Top plate screw.
1	S-324-D	Stereo slide.
2	S-325-D	Shutter spider.
2	S-366-D	Driving arm stud.
2	W-103-D	Driving arm washer.
3	W-126-D	Governor weight.
5	W-145-D	Upper sprocket.
2	W-146-D	Lower sprocket.
5	E-4	Film trap door.
1	E-5	Film heat shield.
5	H-118-E	Film guide holder.
2	H-119-E	Film trap door holder.
1	L-101-E	Auto fire shutter lift lever.

Plate No.	Stock No.	Description.
1	L-109-E	Auto fire shutter lift link.
5	P-100-E	Film trap door pad.
2	P-214-E	Film protector.
1	R-130-E	Lateral guide roller.
1	S-100-E	Auto fire shutter lever screw.
1	S-102-G	Auto fire shutter link ret. screw.
2	S-134-E	Film trap door stud screw.
1	S-138-E	Film trap heat shield retaining screw.
1	S-292-E	Lateral guide roller shaft.
5	S-309-E	Film trap shoes.
1	S-316-E	Auto fire shutter.
5	S-326-E	Film guide retaining spring.
2	S-328-E	Film trap door pad spring.
1	S-337-E	Lateral guide roller spring.
2	S-367-E	Film trap door holder stud
1	T-104-E	Film trap.
4	A-110-G	Framing arm.
3	A-118-G	Picture framing handle arm.
3	B-122-G	Shutter gear bracket.
5	C-192-G	Intermediate shaft retaining collar.
5	C-193-G	Spiral driving gear shaft collar.
4	C-194-G	Spiral driving gear shaft collar.
4	G-111-G	Lower sprocket gear.
3	G-112-G	Main driving gear.
4	G-115-G	Shutter drive bevel gear.
4	G-116-G	Spir. driv. gear with broached hole.
4	G-117-G	Spiral gear
3	G-133-G	Intermediate gear No. 2.
3	G-134-G	Intermediate gear No. 1.
4	G-135-G	Intermediate bevel gear.
4	G-138-G	Bevel gear No. 3.
4	G-142-G	Vertical shaft gear.
4	G-143-G	Bevel gear No. 2.
3	H-121-G	Governor upper link holder.
3	L-104-G	Framing slide lever.
4	L-105-G	Governor lift lever.
3	L-107-G	Picture framing lever.
3	L-114-G	Picture framing connecting link.
3	L-115-G	Picture framing link.
1	N-105-G	Handle friction spring retain nut.
2	N-119-G	Picture framing lever pivot screw nut.
4	R-128-G	Framing slide arm roller.
3	S-142-G	Picture framing lever pivot screw.
2	S-144-G	Framing slide lever stud set screw.
3	S-145-G	Framing slide lever stud spr. ret scr.
4	S-150-G	Governor lift lever pivot screw.
3	S-209-G	Main driving gear retaining screw.
3	S-222-G	Picture framing link screw.
3	S-223-G	Picture framing connecting link screw.
4	S-321-G	Framing slide.
3	S-330-G	Framing slide lever spring.
1	S-341-G	Picture framing handle frict. spr.
2	S-429-G	Lower sprocket shaft.
4	S-443-G	Vertical shaft
4	S-444-G	Intermediate shaft.
2	S-445-G	Upper sprocket shaft.
4	S-446-G	Spiral driving gear shaft.
2	S-447-G	Shutter shaft
1	W-106-G	Picture framing handle friction washer.

The Motiograph, No. 1-A 1916 Model

Note.—While in general appearance the mechanism of the 1916 model Motiograph very closely resembles former models, still the removal of the inside shutter has tended very

greatly to simplify the mechanism and has rendered it much easier for the operator to assemble and disassemble the machine. There are also other important improvements, as will appear further on, among which is the addition of an auxiliary fly wheel, and the substitution of a sliding toggle joint (the parts of which are shown at A, B, C, P. 5) for the ball and socket.

No. 1. Gear Cover M-A, 1-P, P. 2, carries the parts shown

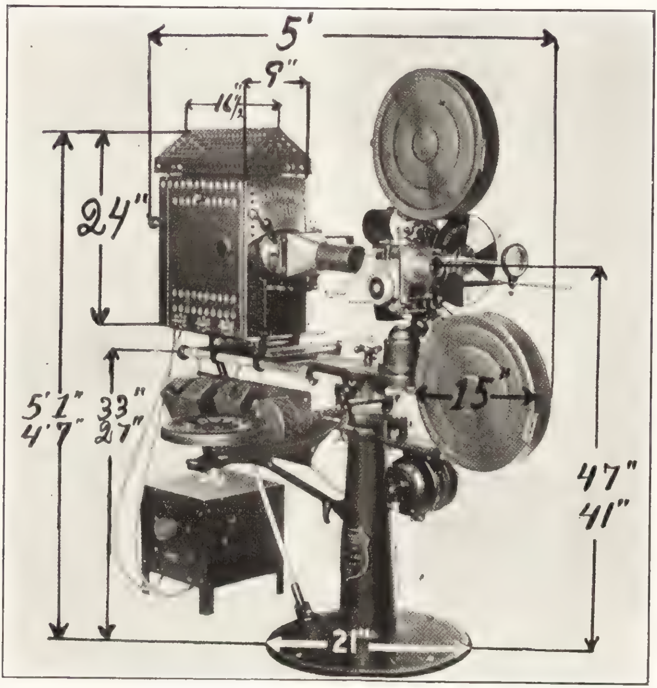


Figure 261.

attached thereto in P. 2. By loosening thumb screws 233 (two of them), P. 2, and thumb screw 233, P. 4, the gear cover may be pulled away, together with the parts attached thereto.

No. 2. The Entire Mechanism may be swung around on

its base, in order to allow the operator to get at the shutter or lens, by loosening the hand wheel underneath the baseboard and raising pin 283½, P. 1.

No. 3. **Front Plate**, 172, P. 4, which carries the objective lens, may be removed by loosening thumbscrews 99-A (two

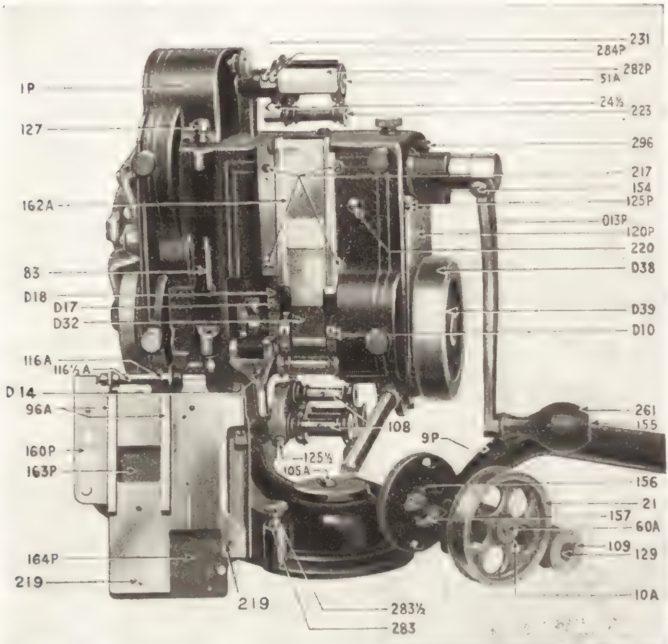


Plate 1, Figure 262.

of them), P. 4, and raising the outer end of spring 275, P. 4, at the top edge of the front plate, at the same time pulling the top of the plate outward and up.

No. 4. The Machine Gate is opened by pressing on knob 125-P, P. 1. This knob is the end of the gate latch rod, which extends inward and carries gate latch screw 220, P. 1, as may be seen by removing the front plate (see Instruction No. 3) and looking inside the mechanism. Gate latch screw 220, P. 1, is threaded into this knob and may be removed

by a screwdriver. Looking inside the mechanism you will see, in the upper left hand corner, a collar on the gate latch rod, held in place by a set screw. This collar serves to compress a small spiral spring. In order to remove this spring, loosen the set screw in the collar and remove screw 220, P. 1, whereupon the gate latch rod may be pulled inward, thus releasing both the collar and spiral spring. Should the gate latch at any time fail to work properly, it is probable that the head of gate latch screw 220, P. 1, has become worn, and a new one should be ordered and installed. It is also possible that the spring has become weak, in which case it should be taken out and either stretched until it gives sufficient compression or a new one may be installed.

No. 5. To Remove the Machine Gate, unscrew knob 127, P. 1, lift governor rack-bar, 168, P. 2, off standard 83, P. 1, and lift the gate away. In replacing the gate *don't forget to hook the end of the rack bar to standard* 83, P. 1.

Caution: It will probably never be necessary to take the gate apart, and if it is for any reason necessary to do so, I would not advise the operator to undertake this particular thing unless he is compelled to. When the gate is once taken apart it is a somewhat difficult matter to reassemble it properly, and I would suggest that instead, should it ever be necessary to make any repairs to its internal mechanism, the gate be sent to the factory. The film tension bars, 96 A, P. 1, and the tension spring can, of course, be removed without taking the gate apart.

No. 6. Aperture Plate, 162 A, P. 1, may be removed by taking out screws (four of them) 217, P. 1. These screws are small, therefore be careful or you will lose them. Better lay a piece of paper underneath to catch them should they fall, or, better still, handle them with a magnetized screwdriver. (See General Instruction No. 19.)

No. 7. Tension Springs and Shoes.—Tension shoes, 96 A, P. 1, are held in place by a one-piece square, flat spring, 174 A, P. 2, which may be seen by looking into the gate edgewise. This spring not only holds the tension shoes in place, but also supplies them with normal tension. The action may be plainly seen by pressing on one of the shoes, at the same time looking into the gate edgewise. Spring 259 P, P. 2, bears on the lower edge of spring 174 A, P. 2, and by means of thumbscrew 245, P. 2, may be caused to supply auxiliary or increased tension to the bottom of the tension shoes. Tension shoes, 96 A, P. 1, may be removed as follows:

Loosen screws 294 and 222, P. 2, and swing cooling plate over to the left out of the way. Next block fire shutter, 163, P. 2, up out of the way. You will then see spring 174 A, which is held by two round-head screws, one at either side of the aperture. First, having backed off on thumb screw 245, P. 2,

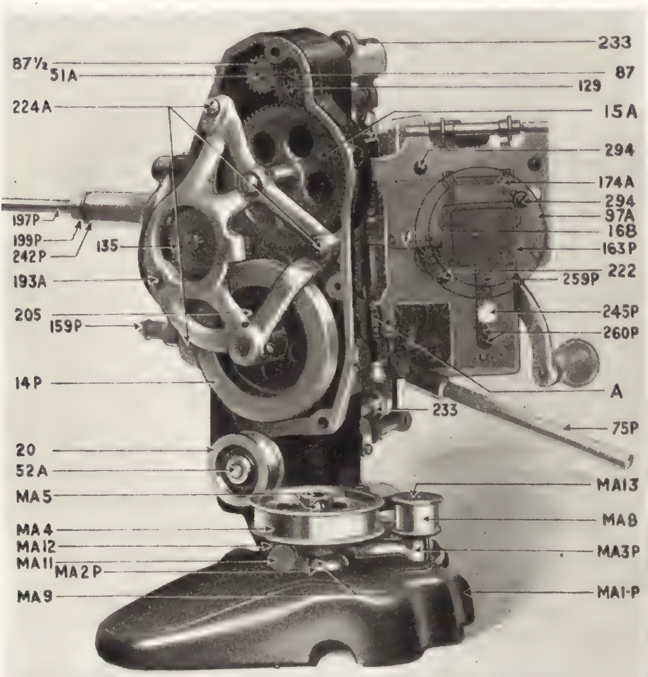


Plate 2, Figure 263.

until spring 259, P. 2, is out of contact with spring 174 A, remove the two screws holding spring 174 A, and pressing in on the tension shoes with the thumb and finger of one hand and in on the top and bottom of spring 174 A, P. 2, with the thumb and finger of the other hand, slip spring 174 A down slightly, which will unhook it from the tension shoes and release both them and the spring.

In replacing the shoes and spring, place the shoes in

proper position so that the hooks on the lugs will point downward, and pressing spring 174 A down flat, slip it up under the hooks until they are engaged, whereupon replace the screws and swing the cooling plate back in place, tighten up its holding screws and the job is done.

No. 8. Automatic Fire Shutter Blade, 163 P, P. 2, may be removed as follows: First follow Instruction No. 5; next remove screws 219, P. 1, and another similar screw about three inches immediately above. Loosen screw, 294, P. 2, and you can lift the entire front plate of the gate away, which will release automatic fire shutter, 163 P, P. 2.

No. 9. Tension Spring, 259 P. 2, may be removed by following Instruction No. 8, and then taking out screws, 260 P, P. 2.

No. 10. Tension.—(See General Instruction No. 9.) The tension may be increased in two ways, first by removing spring, 174 A, P. 2 (see Instruction No. 7), and bending it in proper direction to supply added tension, or by tightening up on thumbscrew, 245 P, P. 2. It is intended that spring 174 A, P. 2, shall supply proper tension without help from spring 259, P. 2.

No. 11. To Remove Upper Sprocket Shield, 282 P, P. 1, remove screws (two of them) 284 P, P. 1.

No. 12. To Remove Upper Sprocket, 106, P. 4, remove the set screw in the center of its hub, and pull the sprocket off the shaft. In replacing it remember that the end having an offset hub goes in toward the casting. If put on the other way the sprocket will be out of line with the aperture, and there will be trouble. Having removed the hub you can pull its spindle 51 A, P. 1 and 2, carrying gear 87½, P. 2, out to the left, first having removed the gear cover. (See Instruction No. 1.)

Caution: In removing upper and lower sprockets you must take the set screw clear out before you can pull the sprocket off.

No. 13. To Remove Upper Sprocket Idler Bracket, 24, P. 4, remove set screw 249, P. 4, loosening screws 227 and 265, P. 4. Next remove top sprocket, 106, P. 4 (see Instruction No. 12), and you can pull the bracket away.

No. 13½. Idler Roller, 108, P. 4, is held away from the sprocket (see General Instruction No. 12) by screw 241, P. 4, which is locked by knurled knob, 241, P. 4. Idler roller, 108, may be removed from its spindle by taking out screw 223, P. 1. I would advise the operator to remove the upper, lower

and the intermittent idler rollers at least once each week, clean and lubricate their spindles, using a medium light oil

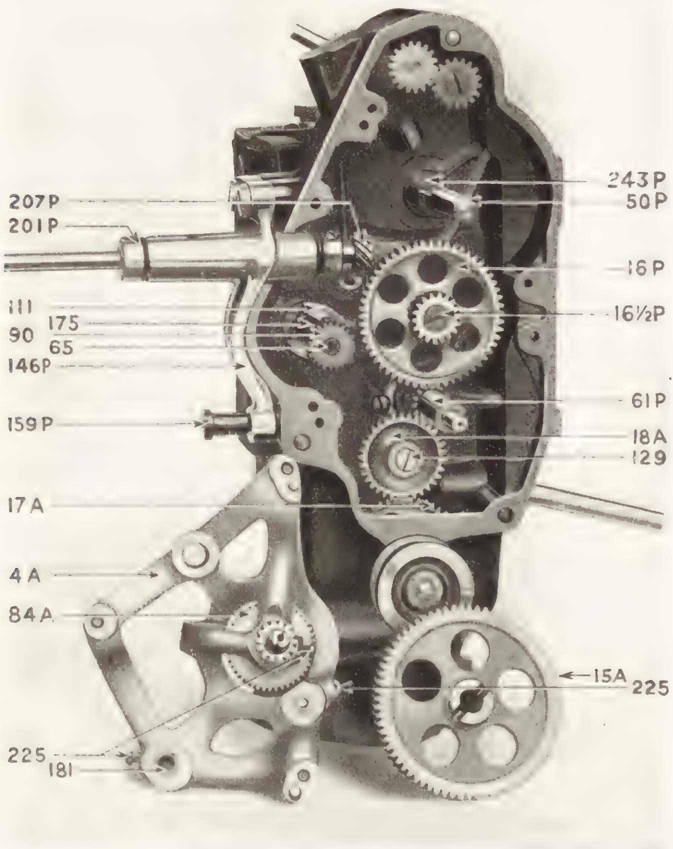


Plate 3, Figure 264.

for the purpose. True, there is an oil hole in their center, but better take them off.

No. 14. Lower Sprocket, 106, P. 4, may be removed by

taking out the screw in its hub and pulling the sprocket off the shaft, first having raised the idler bracket. If it is desired to remove its spindle, 52 A, P. 2, which carries take-up belt driving pulley, 20, P. 2, it will first be necessary to follow Instruction No. 23. Having done so you will see, down in a pocket inside the frame casting, gear 17 A, P. 3, which drives the lower sprocket shaft. Loosen the set screw in its hub, backing it off a considerable distance, as it is deeply countersunk into the shaft, and you can pull the driving pulley and spindle out to the left. In replacing same be sure you get set screw which holds gear 17 A, P. 3, properly located in the countersink in the shaft, and *set it up tight,* because if this set screw works loose it will be a job to get at it and retighten.

No. 15. **Lower Sprocket Idler Bracket,** 25 A, P. 4, may be removed by loosening the screw in the upper end of spring 274, P. 4, and screw 249, P. 4, and screw 227, P. 4. In replacing same be sure to tighten up screw 227, P. 4, and the one on top of spring 274, and to readjust screw 249, P. 4, so that the spring has the proper tension. Lower idler roller, 108 A, P. 4, is merely a guide roller and sets approximately one-eighth of an inch from the sprocket. The other two rollers should, however, be adjusted by means of screw 241¾ and lock nut 241, P. 4, as per General Instruction No. 12. Any of these idler rollers may be removed from their spindle by taking out the screw in the end thereof, but it will be necessary to take off the entire bracket in order to get the center roller off.

No. 16. **Gear Bridge,** 4 A, P. 3, may be removed by taking out screws 224 A (three of them), P. 2. Back these screws out for about one-half inch and then, using a screwdriver, carefully pry the bridge away. The holding screws are "necked," in order that they may be left in the bridge to avoid the possibility of becoming lost. When you have backed them off for about one-quarter inch they will release the main casting, though they are still attached to the bridge. In replacing the bridge be sure that you get the end of the spindle carrying gear 84, P. 3, properly entered in its bearing and also that shaft 50 D, fly wheel shaft 61 P, and the pin entering spindle 65, all P. 3, are properly entered, and that the locating pins enter their proper receptacles. *Do not attempt to drive the bridge on.* If you start it right it will enter without any trouble, and all that will, in any event, be necessary, will be to tap the casting lightly with the handle of the screwdriver immediately over each of the two locating pins.

No. 17. To Remove Revolving Shutter Shaft, 197 P, P. 2, remove screws 159, P. 3, and 158 P, P. 4. You may then pull the spindle and its casting, together with the revolving shutter and gear 207 P, P. 3, out. Having done this, if it is desired to remove the shutter spindle from the casting, you may do so by loosening the set screw in collar, 201 P, P. 3, which will allow you to pull the spindle out of the casting.

Caution: At either end of the shutter spindle bearing is a fibre washer. Be sure and get these washers back in place in reassembling.

No. 18. To Remove Fly Wheel 14 P, P. 2, follow Instruction No. 16, after which remove the two set screws in the hub of the fly wheel. It is better to remove these screws, as they are deeply countersunk into the shaft, then grasping the fly wheel on the other end of the shaft to hold it stationary, twist fly wheel 14 P, P. 2, at the same time pulling outward, and thus working it off the shaft.

Caution: In replacing be sure to get the screws properly located in their countersink.

No. 19. To Remove Gear 87, P. 2, take out set screw 129, P. 2, which releases the gear.

No. 20. To Remove Gear 15 A, P. 2, follow Instruction Nos. 16 and 17, whereupon the gear may be pulled off the spindle.

No. 21. To Remove Crank Shaft 50 P, P. 3, first detach the crank, O-13 P, P. 1, then follow Instruction 20, thus releasing the shaft, which may be pulled out from the left hand or gear side.

No. 22. To Remove Gear 16 P, P. 3, follow Instructions Nos. 16, 17, 18 and 20, in their order, and then take out screw 16½ P, P. 3. This releases the gear. In replacing be sure that you set up screw 16½ P, P. 3, tight.

No. 23. To Remove Gear 18 A, P. 3, follow Instructions Nos. 1, 16 and 18, and then remove screw 129, P. 3. In replacing be sure to set screw 129 up tight.

No. 24. To Remove Gear 17 A, P. 3, follow Instructions Nos. 1, 16, 18 and 23, and then loosen the set screw in the hub of gear 17 A, P. 3. Next loosen the set screw in the face of belt pulley 20, P. 2, and slip the pulley off its shaft. You may then pull spindle 52 A, P. 2, out from the sprocket side, thus releasing the gear..

No. 25. To Remove Automatic Governor Shaft 65, P. 3, and the parts attached thereto, follow Instructions Nos. 1, 16

and 18; then, looking in past the left-hand edge of the fly wheel, you will see a set screw in the hub of a casting in the end of standard 83, P. 1. Loosen this set screw until the casting will revolve on the rod, whereupon you can pull the whole governor away. Should it ever become necessary to renew the springs, gear, or other parts of the governor, I would advise that it be sent to the factory by insured parcel

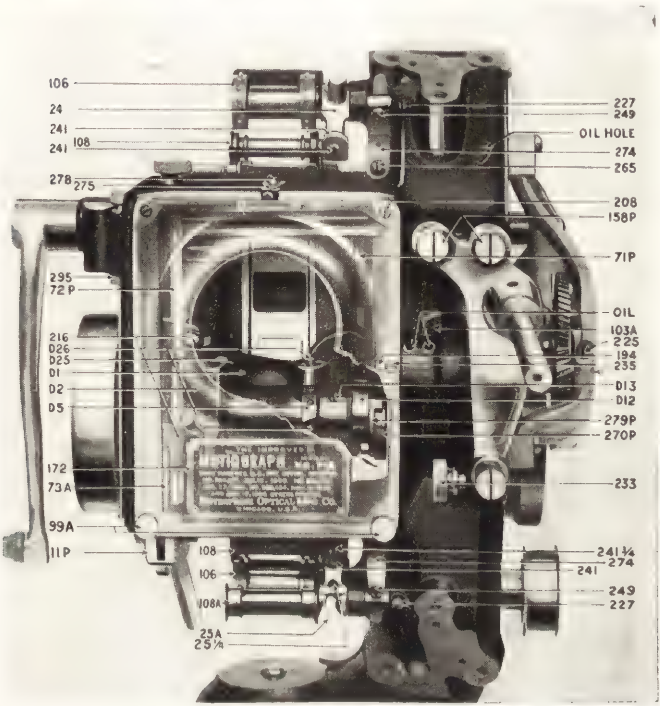


Plate 4, Figure 265.

post. *Don't try to do this particular job yourself.* In replacing the governor the set screw in the casting is countersunk deeply into the shaft, and it is necessary that this screw enter the countersink, else standard 83, P. 1, will not set right, and your automatic fire shutter will not work.

No. 26. **Framing Carriage** D-1, P. 4, carrying outside fly

wheel, D-38, P. 1, may be removed as follows: First loosen screws 216 (two of them), P. 4, and then, by means of knurled knob at its top, unscrew framing carriage guide rod 72 P, P. 4, and pull it out. Next remove the screw which holds the upper end of the link which joins the framing carriage and framing lever casting 11 P, P. 4. Next loosen the two screws, one at each lower corner of the nickel plated shield in the side of the mechanism back of the fly wheel, and raise knob 296, P. 1. You may then, by working it around a little, pull the whole framing carriage out to the right—on the crank side of the mechanism.

No. 27. To Remove Fly Wheel Shaft 61 P, P. 3, follow Instructions Nos. 1, 16, 18 and 26, then loosen a set screw in the face of the framing casting just behind the lower gate hinge. You will be obliged to remove the gate in order to get at this set screw. (See Instruction No. 5.) This set screw holds the bronze bearing in which the shaft runs, and you may then, using either a copper or a hard wood punch, drive the shaft bearing and inner end of the toggle out into the interior of the frame casting.

No. 28. Striper Plate D-32, P. 1, (F-F, P. 5), may be removed by taking out the three screws at its lower end. See P. 5.)

No. 29. Fly Wheel, D-38, P. 1, may be removed by taking out the two set screws in its hub. They are deeply countersunk, and must be backed out for quite a distance before the wheel will be released. When the wheel is released from the screws, hold the fly wheel on the opposite end stationary while you pull the wheel off with a twisting motion.

No. 30. To Open the Oil Well follow Instruction No. 29, and then loosen the screw at each lower corner of the nickel plated shield behind the fly wheel and remove it; next remove four machine screws in the black casting on the end of the framing carriage. These screws hold the cover of well E, P. 5, and having removed them you can pull the cover off, tapping it lightly to break the joint. Before starting this job, you can, if you wish, remove the whole framing carriage from the machine. See Instruction No. 26. It is well to remove the oil well cover, say once in each five or six hundred hours running, and clean it out thoroughly.

Never use graphite in the oil well unless you want trouble, and plenty of it.

Caution: In replacing the oil well cover be sure that you wipe both the surfaces perfectly clean. If you do not there is apt to be a leakage of oil.

Note.—Directions follow for the removal and renewal of cam, star and intermittent sprocket and their bushings. I do not, however, advise this. It is much better to purchase an extra framing carriage, and when anything goes wrong with the old one, or when excessive wear develops in the bushings, spindles, intermittent sprocket, or other parts, insert the new carriage in the machine and send the old one to the factory by parcel post for repairs. It is, of course, possible that the operator can and will make the necessary

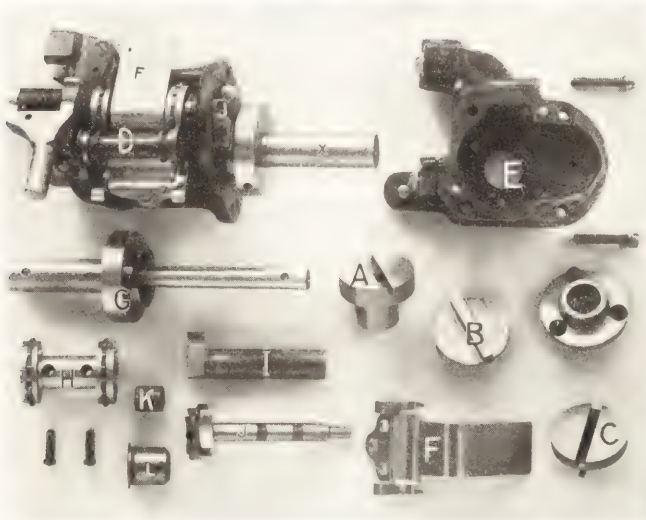


Plate 5, Figure 266.

repairs in an entirely satisfactory manner. Still, when one considers the delicacy of the parts and the fine adjustment necessary, one readily sees that this can be best done at the factory, where all necessary tools and men skilled in this class of work are available.

No. 31. **Cam Shaft** X, P. 5, carrying cam G, P. 5, may be removed by following Instruction No. 30, and then loosening the set screws D-13 (two of them) in part D-12, P. 4. Back these screws out a considerable distance, as they are deeply countersunk in to the shaft. Having done so you can pull the cam and shaft away, which releases part D-12, P. 4.

No. 32. The Star and its Shaft J, P. 5, may be removed by following Instructions Nos. 26, 28, and 31. Having done so, take out the two set screws in the hub of intermittent sprocket D-10, P. 1, and you can pull the star and shaft out.

No. 33. To Remove the Bearings of the Intermittent sprocket Shaft follow Instruction No. 32. The bearing on the star end is held by a set screw, the head of which is in the top of the casting, and the bearing in the other end is held by a set screw in the face of the casting at the end of the bearing. Remove these screws and you can drive the bearing out and insert new ones. The screws in the face of the casting which holds the left hand bearing should be set up just far enough so there is no end motion in the intermittent sprocket. If you set it tight you will bind the sprocket; if you leave it too loose the sprocket is apt to have end play.

No. 34. The Bearings of the Cam Shaft may be removed by following Instructions No. 26 and 31. This bearing extends the full length of the casting. It is held at one end by a set screw, the head of which is in the top of the framing carriage casting; the other end is held by two set screws which bear against the lug in the end of the bearing. This bearing is eccentric. Having loosened the two set screws which bear against the lug, and the one in the top of the casting which holds its other end, you may drive the bearing out, using a hard wood punch. In replacing it it will be necessary to adjust the bearing carefully. Proceed under Instruction No. 35.

No. 35. Adjusting Intermittent Movement.—When the intermittent sprocket develops considerable circumferential play, or the intermittent movement becomes noisy it is in need of adjustment. Proceed as follows. Set screws D-26, P. 4, (two of them), bear against eccentric bearing lug D-5, P. 4, and a movement of these set screws has the effect of altering relation of the star and cam to each other. When you loosen the lower screw and tighten down on the upper one you tighten the cam against the star, thus eliminating the lost motion in the intermittent sprocket, but you must be very careful and not get the movement too tight or you will have trouble, particularly if the adjustment be done while the machine is cold. Tighten up on the upper screw, first having backed off on the lower one, until you can feel just the least bit of shake in the intermittent sprocket when you try it with your finger. Having got your adjustment made tighten up both set screws. This adjustment must be made with the

movement "on the lock"—in position when the sprocket is locked.

No. 36. **Adjusting the Framing Carriage.**—The ease with which the framing carriage moves up and down is governed by screws 216 (two of them), P. 4. Tightening these screws has the effect of pressing together the casting lug on the guide rod, thus making the carriage move harder; conversely loosening these screws makes it move more easily.

No. 37. **Bearings.**—All bearings of the Motiograph machine are held by set screws, and may easily be removed for replacement. Bearing 194, P. 4, is held by set screw 235, P. 4. The bearing which can be seen just at the bottom of gear 207-P, P. 3, is held by set screw 103-A, P. 4. The bearings in bridge 4-A, P. 3, are held by set screws 225 (three of them), P. 3.

No. 38. **Oil.**—*Never under any circumstances use graphite in the oil well.* Graphite is ordinarily one of the finest lubricants made, but it does not work at all satisfactorily in the intermittent movement of a projection machine, nor do I advise its use on gears or on any part of the mechanism. I would advise the use of a very heavy oil, such as Mobile B, which can be had at almost any garage, for the toggle joint. This joint works, under considerable pressure, at high speed. If a light oil be used it is likely to be thrown off rapidly. Mobile B ought to be about right.

No. 39. **Lining the Sprockets.**—See General Instruction No. 4.

No. 40. **Keeping the Sprockets Clean.**—See General Instruction No. 3.

No. 41. **Setting the Shutter.**—See General Instruction No. 18.

No. 42. **Sprocket Teeth.**—See General Instruction No. 8.

No. 43. **Motiograph Take-up** uses a flat belt about one-half inch wide. This belt is driven by pulley 20, P. 2, the driven pulley being shown, not attached to the machine, at 10 A, P. 1. The belt is given the necessary tension by idler pulley 109, P. 1, the tension being governed by set screw 156, P. 1. This plan is quite efficient, but the operator should see to it that the adjustment of idler 109, P. 1, is carefully made, else there will be a heavy pull on the film, which is, of course, injurious.

PARTS FOR MECHANISM OF NO. 1-A MOTIOGRAPH MODEL 1916

Note: In ordering parts give serial number of mechanism and article number. That is all that is necessary.

Numbers in first column indicate plate in which the part is shown.

Plate No.	Article No.	
1—	1-P	Main frame casting of mechanism.
—	3-P	Gear cover.
3—	4-A	Gear bridge.
—	7-A	Upper reel arm, casting only.
1—	9-P	Lower reel arm, casting only.
1—	10-A	Take-up belt tension idler bracket.
4—	11-P	Framing lever casting.
—	12-A	Hand bolt to clamp mechanism to base.
—	13-P	Crank handle casting, only.
1—	013-P	Crank handle complete.
2—	14-P	Balance wheel.
3—	15-A	Main gear.
3—	16-P	Double gear between main gear and balance shaft gear.
3—	16½-P	Screw for double gear No. 16-P.
3—	17-A	Gear on lower sprocket shaft.
3—	18-A	Gear between balance shaft gear and lower sprocket shaft gear.
—	19	Governor crank, complete.
2—	20	Small belt pulley and screw.
1—	21	Large belt pulley and screw.
—	22-P	Stereo lens mount ring.
—	22¼-P	Stereo lens retaining ring.
—	22⅛	Thumb screw for stereo lens mount ring.
—	23¾-P	Stereo lens ring complete, less lens.
4—	24	Roller bracket, upper, with shaft.
4—	24⅛	Screw to bind roller shaft in upper bracket.
4—	25-A	Roller bracket, lower, with shafts.
4—	25¼	Screw to bind roller brackets on shafts.
1—	25½	Screw to bind front eccentric roller shaft in lower bracket.
—	29	Magazine latch, large piece.
—	26½	Spring for magazine latch.
—	30	Magazine latch, small piece.
—	31	Hinge on magazine body.
—	32	Hinge on magazine cover.
—	32½	Spring for magazine hinge.
—	33-A	Fire trap, casting only.
—	33-CT	Fire trap complete, with rollers.
—	F33¾	Spider casting only, for lower magazine.
—	37-P	Stereo lens arm bracket.
—	38-A	Shutter shaft and gear, solid.
—	39-A	Shutter shaft and gear, main, hollow.
—	41-A	Shutter drive shaft screw.
—	42-A	Bushing for governor drive shaft.
—	44-A	Screw for gear on upper sprocket shaft.
—	45-A	Bevel gear on shutter drive shaft.
—	46-A	Bevel gear on shutter shaft.
—	47-A	Intermediate gears in shutter gear case.
—	48-A	Screws for clamping inner shutter wing on gear hub.
3—	50-P	Crank shaft with pin.

Plate No.	Article No.	
1	51-A	Upper sprocket shaft.
3	52-A	Lower sprocket shaft.
	59-A	Upper reel shaft.
	60-A	Lower reel shaft.
3	61-P	Balance shaft and pinion, one piece.
	63-A	Upper fire shield.
	64-A	Lower fire shield.
	65	Governor shaft.
3	65-GC	Governor complete.
	60-A	Bushing for shutter drive shaft.
4	71-P	Framing device guide rod.
4	72-P	Framing device slide rod, long, with head.
4	74	Framing lever connecting screw.
2	75-P	Framing lever handle.
	76	Screw to hold framing lever in frame.
	80-A	Bushing for shutter gear case (rear).
1	81	Shaft for roller brackets.
1	82	Roller arbors for top or bottom roller bracket.
1	82½	Eccentric roller arbor for lower roller bracket.
1	83	Governor crank shaft.
3	84-A	Gear on governor drive shaft.
2	87	Gear on upper sprocket shaft.
2	87½	Intermediate gear, small.
3	90	Gear on governor shaft and hub.
	91	Stereopticon slide rod to hold lens ring.
	91½-M	Wing nut and washer for No. 91.
	92-A	Screw to locate shutter gear case.
	93-A	Screw to retain shutter gear case in frame.
1	96-A	Film tension shoes, each.
2	97-A	Round aperture heat arrester on film gate.
4	99-A	Thumb screw for front plate (2).
	103-A	Screw to clamp shutter drive bushing.

Plate No.	Article No.	
1	105-A	Cap for hole, when changing over '09 screw for clamping mechanism to base.
4	106	Sprocket, upper or lower.
1	108	Idler rolls, hardened steel.
4	108-A	Idler film roll, hardened, lower roller bracket.
1	109	Tension pulley for take-up belt.
3	110	Roller guide on governor shaft.
3	111	Governor balls, brass (two).
	114-A	Shutter gear casing complete with gears.
1	116	Roller, complete for top of gate, with shaft and spring.
1	116-A	Roller, top of gate, solid end, hardened.
1	116¼	Spring for gate roller.
1	116½-A	Roller, top of gate, spring end hardened.
	118-A	Spring for plunger, to locate mechanism on base.
	119	Center pin in hinge of magazine.
1	120-P	Side plate.
	121	Nut, upper reel shaft.
	123	Collar on gate latch rod.
1	125-P	Gate latch rod.
1	126	Shaft for No. 116.
1	127	Ball screw for gate hinge.
	128	Screws to fasten upper or lower reel arm to frame.
3	129	Shaft screw, hardened, for gear or for belt tension pulley or stereo lens bracket.
	133	Pin in governor shaft.
	135	Pin for governor drive gear.
3	146-P	Front shutter bracket casting.
	148	Pin in gear on governor shaft.
1	154	Screw to fasten crank to shaft.
1	155	Screw to hold wood handle on stud.

Plate No.	Article No.	
1	156	Adjusting screw for take-up belt tension pulley.
1	157	Lock nut for screw No. 156.
4	158-P	Front shutter bracket casting, top screw.
4	159-P	Front shutter bracket casting, lower screw.
1	160-P	Main frame of film gate.
	161-P	Front shutter complete, two-wing.
1	162-A	Aperture plate.
2	163-P	Automatic fire shutter and gear.
2	164-P	Heat shield on gate.
4	167-A	Link to connect framing device with No. 11-A.
2	168	Rack bar for fire shutter.
	169	Governor strips.
	170-A	Shutter wing (outer) with collet and screws.
	171-A	Shutter wing (inner).
4	172	Front plate.
	F-173	Stud in crank for wood handle.
2	174-A	Film tension spring to hold No. 96-A.
3	175	Governor spring.
	176-P	Front shutter complete, three-wing.
	178-P	Front shutter blade only.
	179-P	Hub plates for front shutter (2).
	180-P	Hub for front shutter.
3	181	Small bushing in gear bridge for balance wheel shaft.
	182-P	Large bushing for balance arbor.
2	193-A	Bushing in bridge for governor shaft.
4	194	Bushing in frame for governor shaft.
	195-P	Screw for front shutter.
	196-P	Rivets for front shutter.
2	197-P	Front shutter shaft.
2	198-P	Front shutter shaft with gear.
2	199-P	Collar for front shutter shaft.
	200	Screw in governor crank.
3	201-P	Collar screw for front shutter shaft.

Plate No.	Article No.	
	202	Locating screw for idler bracket spring.
	204	Screw for sprockets, upper or lower.
2	205	Screw for balance wheel.
	206-A	Screw for shutter wing collet.
3	207-P	Spiral gear for front shutter shaft.
4	208	Locating screw for front plate.
	209	Screw to fasten magazines to spiders.
2	212	Screw to fasten heat shield to gate.
1	217	Screw for aperture plate.
	218	Screw for lower fire shield.
1	219	Screw for studs on gate.
1	220	Screw for gate latch.
	221	Screw for film tension spring.
2	222	Screw to hold round aperture heat arrester to No. 164-A.
1	223	Screw to hold idler roller on shafts.
2	224-A	Screw to hold bridge on main frame.
2	225	Screw to hold bushings in bridge.
4	227	Locating screw, for roller brackets.
	230-P	Spiral gear for shutter drive shaft.
1	231	Screw for gear cover, upper.
4	232	Screw for gear cover, rear.
2	233	Screw for gear cover, front.
4	235	Screw to clamp governor bushing in frame.
	237-P	Screw for attaching magazine to reel arm.
	238-P	Magazine body and cover.
4	241	Lock nut on roller bracket adjusting screw.
4	241½	Adjusting screw, upper roller bracket.
4	241¾	Adjusting screw, lower roller bracket.

Plate No. — Article No.	
2—242-P	Fibre washers for front shutter shaft.
—243-P	Collar for crank shaft.
—244	Screw for locating crank handle.
2—245-P	Adjustable tension thumb screw.
—247-P	Adjustable tension stud on heat arrester.
4—249	Screw to hold roller bracket in place.
—251-A	Roller for magazine fire trap.
—253-A	Shaft for roll in magazine fire trap.
—255	Screw to hold traps to magazines.
—257	Screw for nut on reel shaft.
—258½-P	Spring for gate latch rod.
2—259-P	Adjustable tension spring.
2—260-P	Adjustable tension spring screw, same as door latch collar screw.
1—261	Wood handle for crank.
—263	Screw for small belt pulley.
4—265	Screw for roller bracket springs.
—267-P	Screw to locate framer guide rod.
—268	Button in magazine latch screw.
—269	Screw for magazine latch.
—271-P	Taper pin for disc on balance arbor.
4—270-P	Disc on balance arbor.
4—274	Spring for upper and lower roller bracket (3 pieces).
4—275	Spring to hold front plate (2 pieces).
—276-P	Set screw to fasten large balance shaft bushing in main frame.
—277-A	Take-up belt.
4—278	Screw for No. 275 springs, front plate.
4—279-P	Disc between framer and balance arbor.
—281-P	Gear on shutter drive shaft.
1—282-P	Guard for upper sprocket.
1—283	Plunger to locate mechanism on base.
1—284-P	Screw for upper sprocket guard.

Plate No. — Article No.	
1—283½	Locating plunger head.
—287-P	Shutter drive shaft with gear 230-P and gear 281-P
—288	Shutter gear case
—289	Screws to clamp bushing in shutter gear case.
—290	Shaft for intermediate gears in shutter gear case.
—291	Screw in gear on lower sprocket shaft..
2—294	Screw for upper fire shield.
2—294½	Screw for heat arrester gate.
1—295-P	Latch pin for side plate.
1—296	Nut for latch pin.
—297	Spring for latch pin.
—298-P	Screw for side plate, same as No. 48-A.
—299	Bushing for shutter gear case (front).
4—D 1	Horizontal main casting.
4—D 2	Vertical casting, cap for D-1.
—D 3	Large bushing for geneva star shaft.
—D 4	Small bushing for geneva star shaft.
4—D 5	Eccentric bushing for geneva cam shaft.
—D 6	Geneva cam and shaft.
—D 7	Geneva driver pin (hardened).
—D 9	Geneva star and shaft (one piece).
1—D10	Intermittent sprocket (hardened).
—D11	Screws for sprocket (hardened) (2).
4—D12	Disc on cam shaft.
4—D13	Screw to fasten D-12 to geneva cam shaft (hardened).
1—D14	Intermittent idler roller bracket and shaft.
—D15	Idler roller, same as No. 108.
—D16	Pin to hold D-14 to D-1.
1—D17	Springs to hold D-14 in position (hardened).
1—D18	Screw to hold D-17 to D-1.
—D19	Adjusting screw for D-14.
—D20	Screw to clamp D-19.

Plate No.	Article No.	
	D21	Screw to clamp roller shaft in intermittent bracket.
	D22	Screw to hold D-15 on shaft, same as No. 223.
	D23	Screw to clamp D-3 in D1.
	D24	Screw to clamp D-4 in D-1.
	D25	Screw to clamp D-5 in D-1.
4	D26	Adjusting screw for D-5 (2).
	D27	Screw to fasten D-2 to D-1.
	D28	Take-up screw to adjust framer on guide rod.
4	D29	Screws in D-2 to adjust friction on slide rod (2).
4	D30	Oil cup on D-2.
	D31	Pin in D-2 for connecting link.
1	D32	Stripper plate.
	D33	Stripper plate screws.
	D34	Dowel pins for D-2.
	D35	Screw to hold D-4 in place.
	D36	Bushing for framer cap No. 02.
	D37	Screw for bushing on D-36.
1	D38	Balance wheel on cam shaft.
1	D39	Balance wheel screw, same as No. 249.
	D40	Intermittent roller arbor.

Plate No.	Article No.	
2	MA 1-P	Gear cover.
2	MA 2-P	Support casting for idler pulley arm.
2	MA 3-P	Idler pulley arm.
2	MA 4	Large belt pulley and screw.
2	MA 5	Socket shaft for large belt pulley.
2	MA 6	Bushing for large belt pulley shaft.
2	MA 7	Small belt pulley and screw for motor shaft.
2	MA 8	Idler pulley.
2	MA 9	Screws to fasten support casting to gear cover (3).
2	MA10	Retaining screw for idler pulley arm.
2	MA11	Adjusting screw for idler pulley arm.
2	MA12	Locking nuts for adjusting screw MA-11 (2).
2	MA13	Screw for idler pulley, hardened.
	MA14	Belt for motor.
	MA16	Motor pulley attachment complete.
	MA17	Plate casting to attach motor to swivel casting on pedestal.
	MA19	Screws to fasten MA17 to swivel casting on pedestal.
	MA20	Screws to fasten motor to plate (4).
	MA21	Nuts for screws MA20 (4).

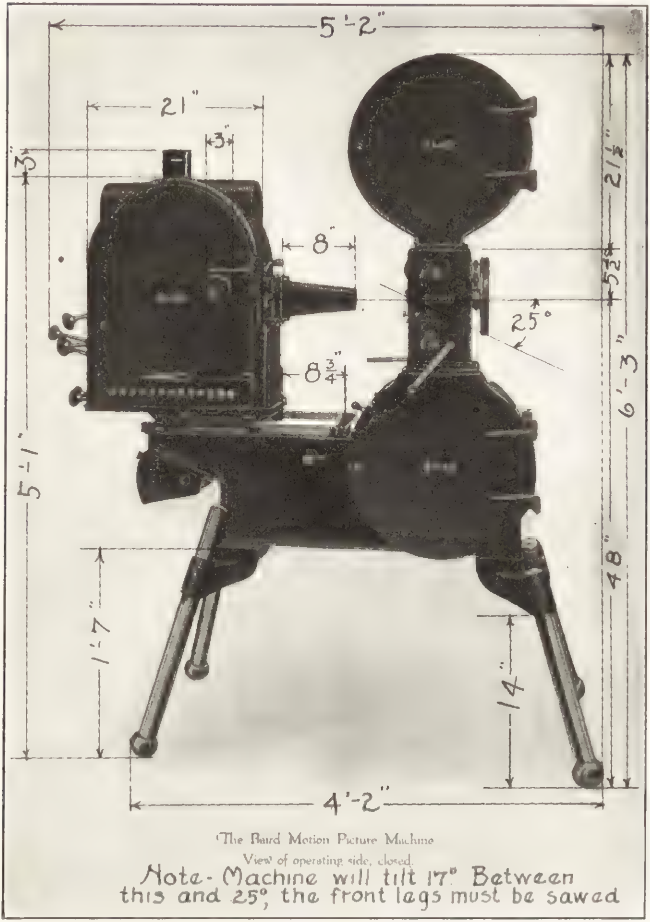
The Baird Machine

THE mechanism of the Baird machine is completely inclosed in a casing composed of three castings of aluminum. These consist of a front plate, a door on the operator's side and a door on the gear side. In addition to this is the gate, which is of cast iron. In the various cuts the casing with the exception of the gate has been removed in order to show the mechanism more completely.

Instruction No. 1.—To remove revolving shutter 310P, P. 2, complete with its housing and lens tube 318P, P. 3, proceed as follows: Loosen screw 867P, P. 1, and pull the entire shutter, including its casing, straight out away from the machine. Shaft 312P, P. 2, which is hexagonal in shape, is not attached rigidly to the mechanism, but telescopes into the hexagonal hole in shaft 130P, P. 3.

No. 2.—In order to remove the casing of the machine, first

follow instruction No. 1, and then remove seven screws which secure the front casing to mechanism. This releases



The Baird Motion Picture Machine
View of operating side, closed.

Figure 267.

the entire casing from the mechanism, including two doors but not including the gate.

No. 3.—To remove the cover for the shutter casing (not shown in the cut) grasp the cover and turn one-quarter inch to the left. It will then be disengaged and can be pulled off.

No. 4.—In order to remove shutter 310P, P. 2, drive out the taper pin in the hub and pull it off the shaft.

No. 5.—To remove shutter shaft 312P, P. 2 and 3, follow instructions Nos. 3 and 4, which will disclose a steel ring containing in its face three machine screws. Take out these screws and pull the ring off, which will release shutter shaft 312P, P. 2 and 3, and its ball bearing. Should it become necessary at any time to replace this ball bearing, you must order the shaft and bearing complete from the manufacturer, as the bearing is placed on the shaft under heavy pressure. The stock number of this shaft is 312P and of the ball bearing 320P. The replacing of this shaft is merely a reversion of the process of its removal, but in replacing the steel ring (stock number 319P) be sure the ball bearing is properly centered before tightening down the three holding screws, else there may be vibration. The best way to accomplish the centering is to put in the three holding screws, tighten them up and then back them off about one full turn. Now start the motor, and while the machine is running, grasp the steel holding ring between your thumb and finger, and you can tell by the sense of touch when it is properly centered; whereupon tighten up the three holding screws *tight*.

No. 6.—The governor, the weight and parts of which are shown at 145P, P. 2, is held by two ball bearings clamped in the holding casting by screws 853P, P. 2. The entire governor, including the ball bearings, may be removed as a unit by following instructions Nos. 1 and 2. Then remove taper pin 70P, P. 2, and pull off arm 117P, P. 2. Next remove screw 141P, P. 2, and a similar screw immediately under the arrow head of 853P, P. 2; this releases bar 140P, P. 2. Next loosen screws 853P, P. 2, whereupon the entire governor including the ball races and beveled gear may be pulled out toward the front.

No. 7.—To remove ball bearing 138P, P. 3, and spring 134P, P. 2, follow instructions Nos. 1, 2 and 6, which releases the governor as a unit. Now remove screw 822P, P. 2, and its mate on the opposite side and tap lightly on the end of shaft 130P, P. 3. The ball bearing is just a tight fit, and by tapping lightly on the end of the shaft with a copper or brass punch it will slip off the shaft, and this releases the governor, weight, spring and sleeve.

No. 8.—To remove spring 134P, P. 2, follow instruction No. 7.

No. 9.—To remove weight 145P, P. 2, follow instruction No. 7, and then drive out the pins holding the governor-

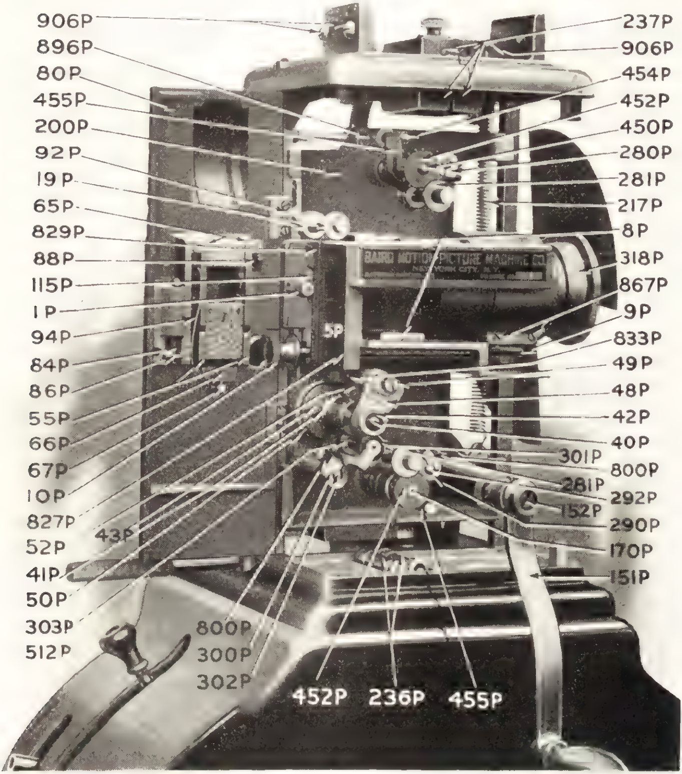


Plate 1, Figure 268.

carrying arms. These pins are not tapered and may be driven either way.

No. 10.—To remove ball race on inner end of governor shaft, follow instruction No. 7, and then drive out taper pin in hub of gear 136P, P. 2. The large end of each taper pin used in this machine may be recognized by a file mark on

the hub behind the head of the pin. Gear and ball race may now be driven off.

No. 11.—To remove flywheel, 26P, P. 2, take out screw in end of shaft and carefully pry off the cap under it, whereupon the wheel may be pulled away. This also releases pinion 27P, P. 2 and 3.

No. 12.—To remove bearing bracket 30P, P. 3, which is also the oil well cover, follow instruction No. 11. Then pull off pinion 27P, P. 3, remove screws 867P (six of them), P. 2, whereupon the bracket including the cam 34P, P. 2, gear 33P, P. 2, and its shaft 25P, P. 2, can be pulled away as a unit. In removing this bracket pull the parts away carefully, moving them straight outward, then up and to the right, being careful not to strain any part, else you may injure the cam pin or the star or both.

No. 13.—To remove cam 34P, P. 2, follow instructions Nos. 11 and 12, and drive out taper pin engaging the hub of what appears to be gear 33P, P. 2, but is in reality the hub of the cam. This will release cam 34P, P. 2, and gear 33P, P. 2. Gear 33P, P. 2, is held to cam 34P, P. 2, by four screws in the back of the cam; by removing these screws the gear is released.

No. 14.—Shaft 25P, P. 2, runs in a bronze bushing pressed into the bracket casting 30P, P. 3. This bushing may be driven out and a new one substituted. The new bushing may be driven in from either direction, but be very careful that you get it started straight, and do not use anything but a hard wood punch to drive it. Proceed carefully and you will have no trouble. The inner end of the bushing should be flush with the casting.

No. 15.—To remove the intermittent unit, which includes shaft 40P, P. 2, star 44P, P. 2, bushing 42P, P. 2, eccentric sleeve 43P, P. 2, collar 45P, P. 2, and intermittent sprocket 41P, P. 2, proceed as follows: Remove screw 49P, P. 1, and pull off bracket 48P, P. 1. Release screws 833P (two of them), P. 1, and take off intermittent stripper 52P, P. 1. Next remove screw 201, P. 2. Then raise up on pin 50P, P. 1, which revolves eccentric sleeve 43P, P. 1, and disengages the star from the cam. The intermittent unit may now be removed by grasping the intermittent sprocket and pulling straight out.

No. 16.—To remove intermittent sprocket 41P, P. 2, follow instruction No. 15 and then drive out the two taper pins in the hub of the sprocket. See recommendation in instruction No. 57.

No. 17.—To remove both bushings 42P, P. 2, follow instruction No. 15, drive out taper pin in the hub of star 44P, P. 2. Intermittent shaft may then be removed from sleeve 43P, P. 2. There are two bushings in this sleeve, and to remove them drive either one clear in against the other bushing and drive the old bushings right on through. In putting in new bushings use nothing but a hardwood punch and be sure to get them started straight. Drive the bushings in at either end of the sleeve until they are flush with the face of the sleeve. See recommendation in instruction No. 57.

No. 18.—The inner end of shaft 25P, P. 2, is carried by a small bronze bushing. To remove this bushing and to replace proceed as follows: First follow instruction Nos. 11, 12 and 15, which removes the entire intermittent mechanism. The hole which holds the bushing carrying the end of shaft 25P, P. 2, extends clear through to the other side, its open end being plugged up with a loosely fitting iron plug. Stick a steel nail or any slim punch through the bushing and drive this plug out. Then the bushing may be driven out from either end and the new one driven in. In driving in the new bushing use nothing but a hardwood punch, and be sure to get it started straight. The new bushing may be driven in from either end and its face must be flush with the casting on the inside end.

No. 19.—Gear 176P, P. 2 and its shaft, gear 163P, P. 2; belt wheel 161P, P. 2; gear 158P, P. 2, and the shaft carrying them may be removed as a unit by first disconnecting the motor and the take up belts 659P and 334P, P. 4, and pulling out the hinge pins 338P and 660P, P. 4, then removing screws 872P, P. 2, and two others in the opposite end of plate 181P. Next remove screw 152P, P. 1, and crank 151P, P. 1, and the taper pin in the shaft behind the hub of the crank. Next loosen screw on the inner end of shaft 455P, P. 1. This screw is on the gate side just between sprocket 452P, P. 1, and the casting. Having released the screws, turn down the stripper plate which comes up between the flanges of the sprocket, and then remove sprocket 452P, P. 1, by loosening the screw in the center of its hub and pulling the sprocket off its shaft; also pull off collar which is on the shaft behind sprocket, after loosening two set screws in its hub. This releases the parts. After having raised the framing carriage as far as it will go, grasp plate 181P, P. 2, and pull the whole thing straight out and away.

Caution.—In replacing this part be careful when you put the lower sprocket 452P, P. 1, back on the shaft that it

centers properly between the flanges of the idler roller 281P, P. 1 (see instruction No. 55), and that the stripper plate is raised up into position between the flanges of the sprocket, and its holding set screw well tightened.

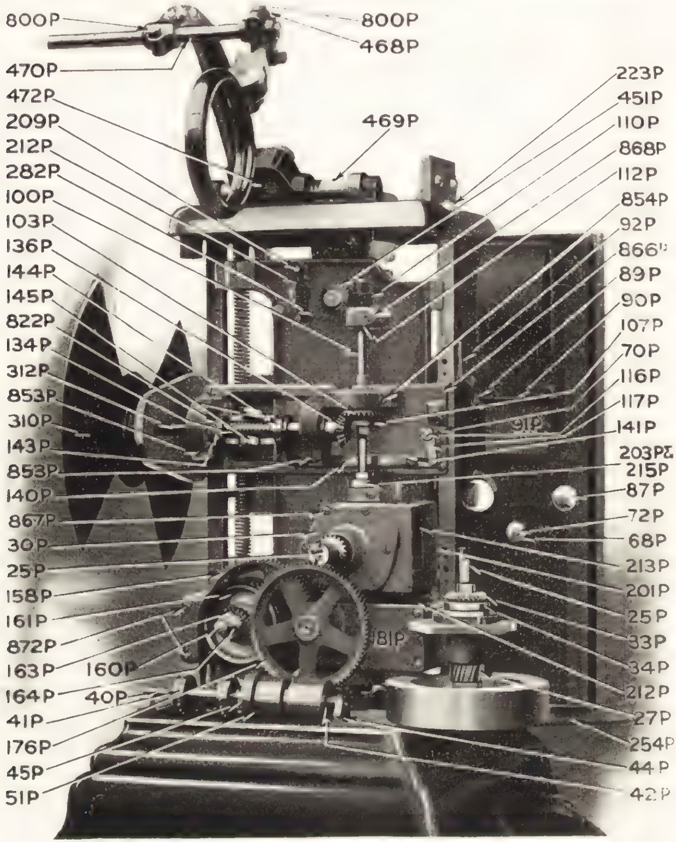


Plate 2, Figure 269.

No. 20.—The method of driving the machine is as follows: When crank driven, gear 158P, P. 2, which is attached to take up belt pulley and to the crank shaft, drives pinion (stock No. 174) which is secured to the lower sprocket shaft 170P,

P. 1. This pinion is just inside the plate 181P, P. 2, and does not show. It drives the lower sprocket shaft and gear 176P, P. 2 and 3, which in turn drives the cam shaft through pinion 27P, P. 2 and 3.

When the machine is motor driven, motor pulley 625P, P. 4, drives friction disc 622P, P. 4, which in turn drives belt 659P, P. 4. Belt 659P, P. 4, drives pinion 163P, P. 2, being attached to pulley 161P, P. 2. Pinion 163P, P. 2, drives lower sprocket shaft gear 176P, P. 2 and 3. Gear 176P, P. 2 and 3, then drives the intermittent movement through pinion 27P, P. 2 and 3.

No. 21.—To remove gear 176P, P. 2 and 3, drive out taper pin in its hub, remembering that the file mark on the hub is at the large end of the pin. Gear can then be pulled off the shaft.

No. 22.—To remove lower sprocket shaft 170P, P. 3, and the inner pinion thereon follow instruction No. 19 and then drive out taper pin in hub of gear 176P, P. 2 and 3, whereupon the shaft can be pulled out on the operating side of the machine.

No. 23.—To remove bronze bushing carrying lower sprocket shaft 170P, P. 1, follow instructions Nos. 19 and 21, whereupon the bushing may be driven out from either direction, using a hard wood block and hammer for the purpose. In replacing this bushing take note that the bushing is longer than the bearing, and be careful that it projects or extends the same distance as the old one.

No. 24.—To remove belt pulley 161P, P. 2, and gear 163P, P. 2, follow instruction No. 21 and then loosen set screws (two of them), in collar 162P, P. 3, after which the pulley and gear can be removed.

No. 25.—To remove gear 158P, P. 2, and the belt pulley attached thereto, follow instruction No. 19, and remove collar 163P, P. 3, whereupon the shaft and gears can be pulled out. Gear 158P, P. 2 and 3, is attached to the crankshaft by means of a taper pin in its hub, and the belt pulley next it is also attached in the same manner.

No. 26.—The crank end of the crankshaft is supported by a bronze bushing. To remove this bushing and replace it with a new one follow instruction No. 19, whereupon the bushing may be driven out from either direction and the new one driven in, using only a hard wood block for the purpose.

No. 27.—Just below the intermittent oil well in the main frame casting is one of the bushings supporting lower sprocket shaft 170P, P. 1. To remove this bushing and re-

place it with a new one follow instruction No. 19, whereupon the bushing may be driven out from either direction and the new one driven in, using a hardwood block for driving.

No. 28.—The springs which hold the idler roller bracket to the sprocket are removed or attached merely by slipping them off the studs.

No. 29.—To remove governor bracket 137P, P. 2 and 3, carrying governor and the center ball race of shaft 100P, P. 2 and 3, follow instructions Nos. 1 and 2, then remove taper pin 70P, P. 2, and arm 117P, P. 2, and pull out shaft 116P, P. 2. Next remove screw 854P, P. 2, and shove upward on gear 103P, P. 2, thus raising both the gear and ball bearing above its supporting casting. Now remove screw 866P, P. 2 (four of them), whereupon part 137P, P. 2 and 3, can be pulled away, carrying with it the governor, gear 136P, P. 2, and link 140P, P. 2.

No. 30.—To remove castings 1P, P. 1, and 2P, P. 3, which support the lens, follow instruction No. 1, then take out taper pin 70P, P. 2, pull out shaft 116P, P. 2, and remove four screws, one at each corner of the casting, first pulling part 2P, P. 3, in by means of knob 10P, P. 1, far enough to expose the two screws in the lens end of the casting.

No. 31.—To remove knob 10P, P. 1, and rod 9P, P. 1, look on the under side of casting immediately below rod 9P, P. 1, at the end next knob 10P, P. 1, and you will find a small screw. This screw engages a groove in shaft 9P, P. 1, and after it has been removed, rod 9P and knob 10P may be removed by screwing it out of the arm of part 2P, P. 3. In replacing this part do not forget to tighten up this retaining screw so that it engages with the groove in the shaft, or else the rod will not operate part 2P, P. 3.

No. 32.—Part 2P, P. 3, is the casting which engages or grasps tube 318P, P. 3, which holds the lens. The lens tube itself rests inside part 318P, P. 3, so that when the parts are assembled and the lens is in place, part 318P, P. 3, and the lens tube are tightly clamped together by screw 867P, P. 1 and 3; and since part 318P, P. 3, carries with it shutter blade 310P, P. 2, and shutter shaft 312P, P. 2 and 3, it follows that by adjusting knob 10P, P. 1, the lens and the shutter blade are both moved inward and outward when the lens is focused, and thus the shutter is maintained at all times at a fixed distance from the lens.

No. 33.—Top guide roller 19P, P. 1, is composed of inner flange 18P, P. 3, outer flange 20P, P. 3, and spreading rollers 19P, P. 1, these being held together by spindle 14P, P. 3,

and spring 16P, P. 3. This part may be dissembled by removing set screw in the supporting casting just back of arrow head 18P, P. 3. The tension of spring 16P, P. 3, may be varied at will by loosening the holding set screw just back of arrow head 18P, P. 3, and moving shaft 14P, P. 3, slightly in or out.

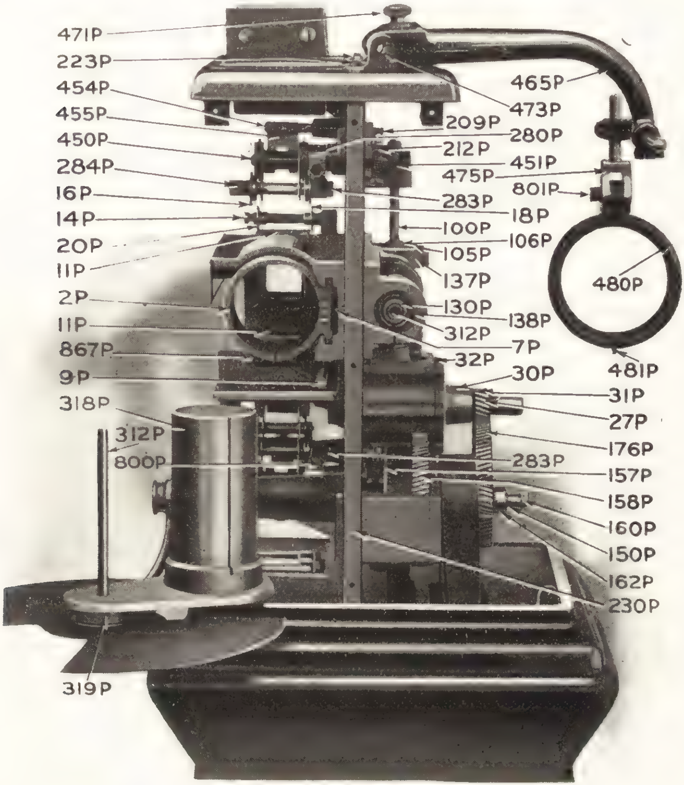


Plate 3, Figure 270.

No. 34.—Aperture plate 5P, P. 1, is held in position by four screws. This plate is made of carbon steel as hard as glass. It may be removed for renewal by taking out four screws, one in each corner.

No. 35.—To remove gate 80P, P. 1, take out the four screws holding the main casting to the posts and then pull the gate away. The hinges are held by dowel pins in addition to the screw.

No. 36.—Automatic fire shutter flap 91P, P. 2, is attached to its shaft merely by being bent around it. Its position on the shaft may be adjusted by holding horizontal rack 88P, P. 1, stationary and lifting or lowering, as the case may be, fire flap 91P, P. 2. Fire flap 91P, P. 2, may be removed by driving out the spindle from the pinion end. In replacing hold the corner of a hardwood block against the pinion and drive the shaft into the pinion, after having shoved the shaft through the fire flap. The rack engaging this pinion may be removed by driving it through the gate away from the pinion; use only a hardwood punch for this purpose, the door of course being open or off the machine. This rack should be kept clean and perfectly free at all times, since the shutter drops by gravity alone.

No. 37.—Each of tension shoes 65P, P. 1, is pivoted to a plunger which passes through the gate casting, the shoes being held up against the film by a flat spring, the lower end of which is seen at 66P, P. 1. The tension on this spring is regulated by nut 68P, P. 2, which is attached to a steel screw 67P, P. 1. Thus the operator at all times is able to give his tension the finest possible adjustment. Spring 66P, P. 1, is so pivoted that it automatically equalizes the tension between the two shoes.

Lower tension shoes 55P, P. 1, are attached to plate 58P, P. 1, and are held up by a small flat yoke spring at its rear. Plate 58P, P. 1, and lower tension shoes 55P, P. 1, may be removed by taking out screw 878P, P. 1, on the upper end of the plate. Upper tension shoes 65P, P. 1, may be removed by pressing in on the lower end of the shoe until the upper end comes out of its engaging slot; turn upper end toward center of the gate. It will then be released from its pivot pin.

No. 38.—Spring 94P, P. 1, is held by two screws at its lower end, and serves to hold the film over against the steel track at the left of the aperture. It also prevents side motion. The main tension spring supplies tension to the upper shoes. To remove this spring, remove screw 72P, P. 2, in the center of nut 68P, P. 2, taking off nut 68P, P. 2, and pulling out pin 67P, P. 1. In replacing the spring be sure that the depression in its face rests on the fulcrum properly

and that its upper ends engage with the plungers of the tension shoes.

No. 39—Upper sprocket 452P, P. 1, may be removed by loosening the screw holding stripper spindle 454P, P. 1 and 3. Swing the stripper up out of the way, loosen the set screw in the hub of the sprocket, and pull sprocket off. In replacing sprocket be careful to get it properly centered between the flanges of its idler rollers.

No. 40.—Upper sprocket shaft 450P, P. 1 and 3, and gear 451P, P. 2 and 3, may be removed by following instruction No. 39 and then removing collar 453P, P. 1, by loosening set screws (two of them) in its hub, afterward pulling shaft and gear out.

No. 41.—To remove gear 110P, P. 2, drive out the taper pin in its hub and raise the gear off by revolving it until it disengages from the teeth of 451P, P. 2 and 3.

No. 42.—To remove shaft 100P, P. 2 and 3, remove screw in top of mechanism which engages main supporting spring 217P, P. 1, then remove nuts 223P, P. 3, and take out the two top screws holding machine case to the top of mechanism, which will allow the whole top of the machine to be taken off. Next release screw 854P, P. 2, and upper and lower screws 868P, P. 2. Now follow instruction No. 12, look into the oil well and see the bevel gear on lower end of shaft, attached thereto by a taper pin, remembering that the file mark is at the large end of the pin. Drive this pin out. Next loosen two set screws in collar resting on part 203P, P. 2, and 215P, P. 2, whereupon shaft 100P, P. 2, may be lifted out upward.

No. 43.—The mechanism is held to the lower magazine by four screws, the heads of which are seen by looking underneath the edge of the casting in the top of the lower magazine. Remove these four screws and you may lift the whole mechanism away.

No. 44.—The framing of the carriage is accomplished by means of a segment of a gear and pinion attached to the side of the base of the mechanism. Should anything at any time go wrong with this mechanism you can get at it by removing the machine from the base, whereupon its method of dissembling is self-evident. The framing mechanism under the base operates a vertical screw 247P, P. 4, which engages with a phosphor bronze nut attached to the center of the framing carriage.

No. 45.—The weight of the framing carriage is carried by

a vertical spring 217P, P. 1, and if there is a tendency for the carriage to work down proceed as follows: Open the motor compartment door, and looking up at the bottom of the mechanism you will see a half round arrangement with a cap and three screws; this is open at one side. Looking in you will see a small nut which has a right-hand thread. By tightening this nut slightly the tension on the framing handle is increased. Later design has a plate supported by two lugs in place of the half round support, the adjustment being the same.

No. 46.—Where it is desirable to use half-size lens the company furnishes a special mount with a revolving shutter. The half-size lens cannot be used with the regular mount as shown at 318P, P. 1 and 3.

No. 47.—To remove motor drive unit disconnect wires leading to switch and remove belt 659P, P. 4, by taking out pin 669P, P. 4. Looking under casting 621P, P. 4, you will see a horizontal link connected to a vertical lever by a screw. Remove this screw. Next take off nut securing upper end of toggle link to casting 621P, P. 4. Remove screw 658P, P. 4. Motor unit may now be taken out as a whole. Motor may be removed from casting 621P, P. 4, by removing screws in bottom of casting 621P, P. 4, and screws in coupling 650P, P. 4.

No. 48.—In order to remove driving friction wheel which bears on friction disc 622P, P. 4, first follow instruction No. 47, then remove 638P, P. 4, from shaft 635P, P. 4. This key is held in position by a screw in its face. Next remove three screws in the face of the leather washer 633P, P. 4, which will release disc wheel.

No. 49.—To remove the friction material on face of 625P, P. 4, follow instructions Nos. 47 and 48 and then remove screws in the outer end (you cannot see them in the cut) of the friction wheel. This releases the friction material, which may be removed and new material be secured from the manufacturer and put in its place. The friction material will need no turning or trueing up after being put in.

No. 50.—To remove disc wheel 622P, P. 4, release the set screw in the belt pulley on the shaft of the disc, after first having released the screw in the rim of knurled adjusting nut on the rear end of the shaft. Back this nut off, whereupon you may pull the friction disc and shaft away.

ADJUSTMENTS.

No. 51.—To adjust the intermittent sprocket and cam in order to eliminate lost motion in the intermittent, first loosen screw 201P, P. 2, and screw 49P, P. 1, after which slightly turn eccentric sleeve 43P, P. 1, by pressing down on projecting pin 50P, P. 1, at the same time revolving the flywheel by hand. When you think you have it just about right tighten up screw 201P, P. 2, and try the intermittent sprocket with your fingers. See General Instruction No. 5. When you have the adjustment made to your satisfaction tighten up screw 49P, P. 1, and the adjustment is completed.

Caution: Should you, for any reason, remove bracket 48P, P. 1, be very sure that its face and the face it fits on are perfectly clean when you put them back, because dirt might and probably would throw the part out of line and cause shaft 40P, P. 1, to bind in bushing 42P, P. 1. Also be very sure that screw 201P, P. 2, is set up tight. If it is not it will cause trouble.

No. 52.—End motion in the intermittent sprocket (see General Instruction No. 7) may be removed by loosening the screw in the steel collar between intermittent sprocket 41P, P. 1, and eccentric sleeve 43P, P. 1, and prying lightly against the rim of the sprocket with a screwdriver, letting the point of the screwdriver rest on the collar, which will have the effect of forcing the sprocket to the right and the collar to the left. Tighten up the screw in the collar while it is held in this position.

No. 53.—In threading the machine, when you raise the lower sprocket idler do not jerk it up as though you were working with a two-inch bar. Rough handling of this idler may get it out of line with the sprocket, which will cause the losing of the lower loop. (See General Instruction No. 12.)

No. 54.—The quantity of oil in oil well 213P, P. 2, should only be sufficient so you can see the oil splash on the oil window when the machine is running. In order to clean out oil well 213P, P. 2, remove the screw immediately below the glass window, which will allow the oil to drain out, you of course providing something for the oil to run into. Replace the screw, flood the well with kerosene, and give the machine a few turns, after which remove the screw, drain out the kerosene and put in fresh oil. (See General Instruction No. 1.)

No. 55.—With regard to the idler rollers (see General Instruction No. 12), in order to change the distance of idler rollers from the sprocket, loosen the clamping screw in the

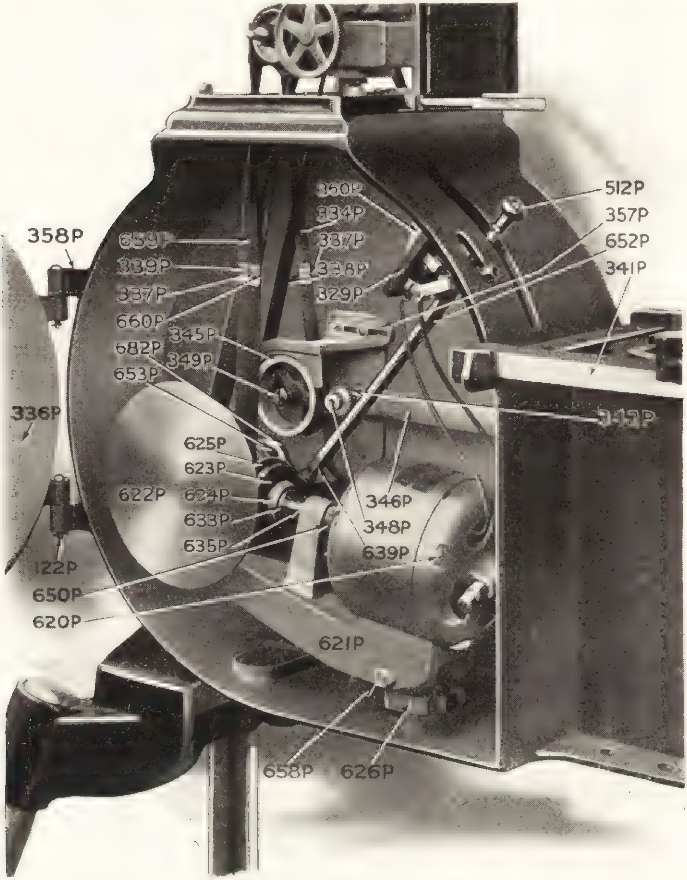


Plate 4, Figure 271.

hub of bracket, one of which is shown at 800P, P. 1, which will allow of moving the bracket on its shaft. In making this adjustment be very careful not to move the hub of bracket

away from the main casting, which would cause the idler to be out of line with the intermittent sprocket.

No. 56.—Upper and lower sprockets may be turned end for end on their shafts in order to present a new tooth surface to the film, if the teeth are worn on one side.

No. 57.—I would by all means advise all purchasers of the Baird machine either at the time of purchase or later on to secure a complete part comprised of 40P, 41P, 51P, 42P and 44P, P. 2. Then when your intermittent sprocket, shaft, bushing or star is worn, all you have to do is to remove the complete part, substitute the new one and send the old one to the factory for inspection and repairs. This is in every way much better than to attempt to put on a new intermittent sprocket. The intermittent sprocket is the heart of a moving picture machine, and it must not only be true down to as little as one ten-thousandth of an inch, but it must be mounted absolutely true also, and the operator is seldom in a position to do a delicate job of this kind properly.

No. 58.—The wear of the bushing carrying shaft 170P, P. 1, supporting lower sprocket 452P, P. 1, will have the effect of increasing the distance between the sprocket and its idler. Should you begin to have trouble with losing the lower loop, first see if you can move the outer end of the lower sprocket up and down perceptibly. If you can, the bushing is probably somewhat worn and the distance between sprocket and idler has increased. The remedy is to loosen the idler. (See Instruction No. 55.) When you are making this adjustment hold down on the sprocket; then adjust idler roller to suit this condition.

No. 59.—There should be just sufficient pressure between friction disc wheel 622P, P. 4, and driving friction wheel to cause disc wheel 622P, P. 4, to continue to revolve when belt 659P, P. 4, is slipping on pulley. This pressure is regulated by a knurled nut at the rear end of the shaft, carrying disc-wheel 622P, P. 4. To test the drive, start the motor and grasp the flywheel firmly, causing the belt to slip on the pulley. Any unnecessary pressure between friction disc-wheel 622P, P. 4, and the driving friction wheel will cause excessive wear and loss of power and probably heating of the motor.

No. 60.—At the lower end of rod 639P, P. 4, is a casting supported by a stud attached to the rear wall of the compartment. This casting is supported on the stud by a clamp lined with fibre. Should at any time the knob 512P, P. 4.

develop a tendency to work up or down while the motor is running, tighten the screw in this clamp bushing sufficiently to hold the rod in place and prevent the knob from moving through vibration of parts.

No. 61.—On the operating side of the machine at the bottom of the magazine is a horizontal lever, the purpose of which is to raise the discwheel end of part 621P, P. 4, thus releasing belt 659P, P. 4, which operates as follows: When ready to start the show raise the lever up and start your motor by throwing in the handle of switch 329P, P. 4, next set speed regulating knob 512P, P. 4, in running position, if it is not already there. Now when you are ready to project the picture drop the lever slowly down with one hand and as the fire shutter raises raise the dowser with the other hand.

No. 62.—Belt 334P, P. 4, operates the take-up. The take-up gear 342P, P. 4, is on take-up spindle, 348P, P. 4, which carries the lower reel. This spindle is supported by bar 346P, P. 4, which is hinged to the machine casting on the opposite side, just back of the figures 342P, P. 4. The front end of this lever, including the take-up spindle, rests in and is supported by belt 334P, P. 4. The result is that when the reel in the take-up magazine is empty there is very little friction on this belt, but as the film is wound on the reel the weight increases, and thus an automatically regular take-up tension is supplied in excellent form.

No. 63.—Any angle may be given the machine as a whole by loosening the clamps which secure the legs and raising or lowering the machine to secure the desired setting.

No. 64.—The condenser is supported in a metal casing which forms a heat reservoir and will go far toward reducing lens breakage. The casing is so designed that it may be adjusted to suit various conditions. It is advisable that the lens be kept about one-sixteenth of an inch apart.

No. 65.—On the top of the carbon clamp of your lamp, under the clamping screw, is a hole which should be kept filled with powdered graphite at all times. Do this and you will have no trouble with your carbon clamp screws working hard.

No. 66.—The cups on the motor should be kept filled with a good grade of medium oil.

NAMES AND NUMBERS OF PARTS FOR BAIRD MACHINE

Order parts by number only. These numbers are the manufacturers' regular stock numbers. The first column indicates the number of the plate or plates upon which the part appears.

1	— 1P	Bracket for lens and aperture plate.
3	— 2P	Slide for ¼ size lens and shutter guard.
1	— 5P	Aperture plate.
3	— 7P	Spring between lens bracket and slide.
1	— 8P	Frame to hold glass on lens bracket.
3 & 1	— 9P	Screw to adjust lens.
1	— 10P	Knob of lens adjusting screw.
3	— 11P	Glass for lens bracket.
3	— 14P	Pin for film guiding roller.
3	— 16P	Spring for film guiding roller.
3	— 18P	Roller for back edge of film.
1	— 19P	Spreader roller for guiding film.
3	— 20P	Roller for front edge of film.
2	— 25P	Cam shaft.
	— 26P	Fly wheel.
3 & 2	— 27P	Pinion for cam shaft.
	— 28P	Washer for fly wheel.
	— 29P	Screw to hold fly wheel pinion on cam shaft.
3 & 2	— 30P	Bracket for outside bearing on cam shaft—cover for oil well.
3	— 31P	Bushing for outside bearing on cam shaft.
3	— 32P	Gasket for cam shaft bearing.
2	— 33P	Bevel gear on cam shaft.
2	— 34P	Cam.
1 & 2	— 40P	Intermittent shaft.
1	— 41P	Intermittent sprocket.
2 & 1	— 42P	Bushings for intermittent shaft.
1	— 43P	Eccentric sleeve.
2	— 44P	Star wheel.
2	— 45P	Collar on intermittent shaft.
1	— 48P	Bracket for outside bearing on intermittent shaft.
1	— 49P	Screw for bracket on intermittent shaft.
2	— 50P	Pin to adjust eccentric sleeve.
2	— 51P	Gasket for eccentric sleeve.
1	— 52P	Stripper for intermittent sprocket.
1	— 55P	Lower tension shoe.
	— 59P	Spring for lower tension shoe.
1	— 65P	Upper tension shoe.
1	— 66P	Spring for upper tension shoe.
1	— 67P	Adjusting screw for upper tension shoe.
2	— 68P	Adjusting nut for upper tension shoe.
2	— 72P	Screw stop for adjusting nut for upper tension shoe.
1	— 80P	Gate.
	— 81P	Spring for locking pin on gate door.
1	— 84P	Plunger for locking gate door.
	— 85P	Pin for releasing locking plunger on gate door.
1	— 86P	Foot on gate door plunger.
2	— 87P	Knob for releasing pin on gate.
1	— 88P	Rack for fire shutter.
2	— 89P	Pinion for fire shutter.
2	— 90P	Shaft for fire shutter.
	— 91P	Fire shutter.
1 & 2	— 92P	Hinges.
1	— 94P	Spring for edge of film.
3 & 2	—100P	Vertical shaft.
	—101P	Bevel gear on lower end of vertical shaft.
2	—103P	Bevel gear on center of vertical shaft for D. C. machine.
	—104P	Ball bearing for center bevel gear on vertical shaft.
3	—105P	Bevel gear on center of vertical shaft for A. C. machine.
3	—106P	Nut for center bevel gear on vertical shaft.

2	—107P	Driving collar on vertical shaft.
2	—110P	Gear on top end of vertical shaft.
2	—112P	Bushing for top end of vertical shaft.
1	—115P	Lever engaging fire shutter rack.
2	—116P	Shaft carrying levers operating fire shutter.
2	—117P	Lower lever operating fire shutter.
3	—130P	Governor shaft.
	—131P	Pins for governor balls.
	—132P	Pins for collars on governor shaft.
2	—134P	Spring for governor for D. C. machine.
	—135P	Bevel gear on governor shaft for A. C. machine.
2	—136P	Bevel gear on governor shaft for D. C. machine.
3	—137P	Bracket carrying governor shaft.
3	—138P	Ball bearings on governor shaft.
	—139P	Spring for governor for A. C. machine.
2	—140P	Link connecting governor and fire shutter.
2	—141P	Screws to guide governor connecting link.
	—142P	Sleeve on governor shaft.
2	—143P	Fixed collar on governor shaft.
2	—144P	Sliding collar on governor shaft.
2	—145P	Balls for governor.
	—146P	Arm for governor.
3	—150P	Crank handle shaft.
1	—151P	Crank arm.
1	—152P	Screw to hold crank arm.
	—155P	Driving pin in crank handle shaft.
3	—157P	Pulley on crank handle shaft.
3 & 2	—158P	Helical gear on crank handle shaft.
3 & 2	—160P	—Oil cup on end of crank handle shaft.
2	—161P	Pulley for motor belt on crank handle shaft.
3	—162P	Collar on crank handle shaft.
2	—163P	Pinion on crank shaft for motor drive.
2	—164P	Bushings for pinions on crank handle shaft.
1	—170P	Lower sprocket shaft.
	—174P	Pinion on lower sprocket shaft.
3 & 2	—176P	Helical gear on lower sprocket shaft.
	—181P	Bracket for carrying lower driving gears.
	—185P	Bushing for gear end of crank handle shaft.
	—186P	Bushing for gear end of lower sprocket shaft.
1	—200P	Sliding main frame.
2	—201P	Screw to lock eccentric sleeve.
	—202P	Bushing for inside bearing on cam shaft.
2	—203P	Bushing for lower end of vertical shaft.
	—205P	Bushing for upper sprocket shaft.
	—206P	Bushing for crank end of crank handle shaft.
	—207P	Bushing for sprocket end of lower sprocket shaft.
2 & 3	—209P	Hook pins for bracket springs.
	—210P	Nut for framing.
	—211P	Plug for cam shaft bearing hole.
2 & 3	—212P	Spring for sprocket brackets.
2	—213P	Glass in front of oil chamber.
	—214P	Glass in top of oil chamber.
2	—215P	Cup for bushing on lower end of vertical shaft.
1	—217P	Spring to support main frame.
	—220P	Post carrying gate door.
3 & 2	—223P	Nuts for top of posts.
	—224P	Nut for bottom of posts.
3	—230P	Post for front end.
1	—236P	Rollers for upper and lower fire valves.
1	—237P	Pins for upper fire valve rollers.
	—249P	Pinion on framing screw.
	—251P	Spring on framing screw.
	—253P	Gear for framing
2	—254P	Handle for framing.
	—256P	Bracket for fire rollers, front.

	—257P	Pins for lower fire valve.
	—258P	Bracket for fire rollers, rear.
	—259P	Fibre washer for framing screw.
3 & 1	—280P	Bracket carrying roller for upper sprocket.
1	—281P	Rollers for upper and lower sprockets.
2	—282P	Arm for spring on roller bracket shaft.
3	—283P	Nut for sprocket roller shaft.
3	—284P	Shaft for upper and lower sprocket rollers.
	—290P	Bracket carrying roller for lower sprocket.
1	—292P	Shaft for bracket for lower sprocket.
1	—300P	Bracket carrying roller for intermittent sprocket.
1	—301P	Shaft for roller for intermittent sprocket.
1	—302P	Shaft for bracket for intermittent sprocket.
1	—303P	Roller for intermittent sprocket.
2	—310P	Shutter for D. C. machine.
	—311P	Hub for shutter.
2 & 3	—312P	Shaft for shutter.
	—313P	Washer clamp for shutter.
1 & 3	—318P	Tube carrying lens.
3	—319P	Casing for ball bearing.
	—320P	Ball bearing.
	—321P	Shutter for A. C. machine.
4	—329P	Switch for motor.
4	—334P	Belt to drive lower reel.
3	—336P	Door for motor compartment.
4	—337P	Fastener for belt.
4	—338P	Rawhide pin for belt fastener.
4	—339P	Rivets for driving belt.
	—340P	Stationary bracket carrying lamphouse.
4	—341P	Track bars for stationary bracket.
4	—342P	Gear on lower reel shaft for small reel 1¾ core.
4	—345P	Gear and pulley for driving lower reel.
	—346P	Arm carrying lower reel.
4	—348P	Shaft for lower reel.
4	—349P	Pin carrying pulley on lower reel arm.
	—350P	Collar on lower reel shaft.
	—351P	Latch for lower reel shaft.
	—352P	Plunger in lower reel shaft.
	—353P	Spring in lower reel shaft.
	—354P	Pin for latch in lower reel shaft.
4	—357P	Guard for belt on arm carrying lower reel.
3	—358P	Lug for hinge on stand.
4	—360P	Bracket for motor switch.
1 & 3	—450P	Shaft for upper sprocket.
3 & 2	—451P	Gear on upper sprocket shaft.
1	—452P	Upper sprocket and lower.
	—453P	Collar on upper sprocket shaft.
3 & 1	—454P	Shaft for upper sprocket stripper.
3 & 1	—455P	Stripper for upper sprocket and lower.
3	—465P	Main arm carrying stereopticon.
2	—468P	Coupling between stereopticon arm and lens.
2	—469P	Rack for stereopticon arm.
2	—470P	Rod for stereopticon arm.
2 & 3	—471P	Knob for adjusting stereopticon.
2	—472P	Pinion for stereopticon.
3	—473P	Pivot pins for stereopticon rack.
3	—475P	Yoke end for stereopticon.
	—476P	Collar on stereopticon rack.
3	—480P	Housing for stereopticon lens.
3	—481P	Retaining ring for 2⅞" stereopticon lens.
	—482P	Stereopticon lens 2⅞"
4	—621P	Frame for friction drive.
4	—622P	Friction driven disc.
4	—623P	Hub for driving friction wheel.
4	—624P	Arm for moving driving friction wheel.
4	—625P	Face for driving friction wheel.

4	—626P	Pivot base for motor frame.
	—627P	Clamp washer for face of driving friction wheel.
	—628P	Pulley on shaft of driven friction disc.
	—629P	Bushing for driven friction disc shaft.
	—630P	Bushing for ball bearing end of driven friction disc.
	—631P	Bushing for driving shaft on motor drive.
	—632P	Adjusting nut for driven friction disc.
4	—633P	Retaining washer on hub of driving friction wheel.
4	—635P	Shaft for driving friction wheel.
4	—639P	Friction lever for moving friction wheel.
4	—650P	Leather band for flexible coupling.
4	—652P	Rod for speed control.
4	—653P	Ball bearings for friction drive.
4	—659P	Belt for motor drive.
4	—660P	Rawhide pin for driving belt fastener.
2 1 3	—800P	Clamp screws.
2	—822P	Stock screw.
1	—827P	Stock screw.
1	—829P	Stock screw.
	—801P	Clamping screw.
1	—833P	Machine screw, stock.
2	—853P	Stock machine screw.
2	—854P	Stock machine screw.
3 & 2	—867P	Stock machine screw.
2	—868P	Stock machine screw.
2	—872P	Stock machine screw.
1	—896P	Stock machine screws.
1	—906P	Stock machine screw.
2	—866	Stock machine screw.
2	— 70	Pin.
3	—801	Nut holding housing 480 to yoke 475.
4	—122	Pin for hinge of door 336.

American Standard—"Master Model"

No. 1.—To Remove the Gate, loosen screw 525, P. 1, and pull shaft 506, P. 3, out to the right. In order to get at screw 525, P. 1, it may be necessary to take the mechanism loose from its base and stick a screwdriver up through a hole in base casting immediately under the screw. Before starting to take off the gate, drop the framing carriage clear down, or else the gate will not pass the film chute.

No. 2.—To Remove the Lower Sprocket Film Chute, A-P 17, P. 2, and gear 454, P. 2, first follow Instruction No. 1, then drive out the taper pin in the center of the hub of lower sprocket, 443, P. 2, and the taper pin in the hub of gear 454, P. 2. You can then pull the shaft out to the left, driving it with a copper punch if necessary. Be sure and drive the taper pin the right way.

No. 3.—To Remove Lower Sprocket 443, P. 2, follow Instruction Nos. 1 and 2.

No. 4.—To Remove Gear, 454, P. 2, follow Instruction Nos. 1 and 2.

No. 5—To Remove Film Slide, A-P 18, P. 2, carrying with it film cradle 382, P. 2, and film guiding spool 536, P. 2, follow Instruction Nos. 1 and 2, and then remove screw 527, P. 2, at the lower end of the film slide, and screws (two of

them) 501, P. 2, and screws 526 (two of them), P. 2. The dark metal part 382, P. 2, a portion of which is seen below and a portion above the aperture, is all in one piece and is

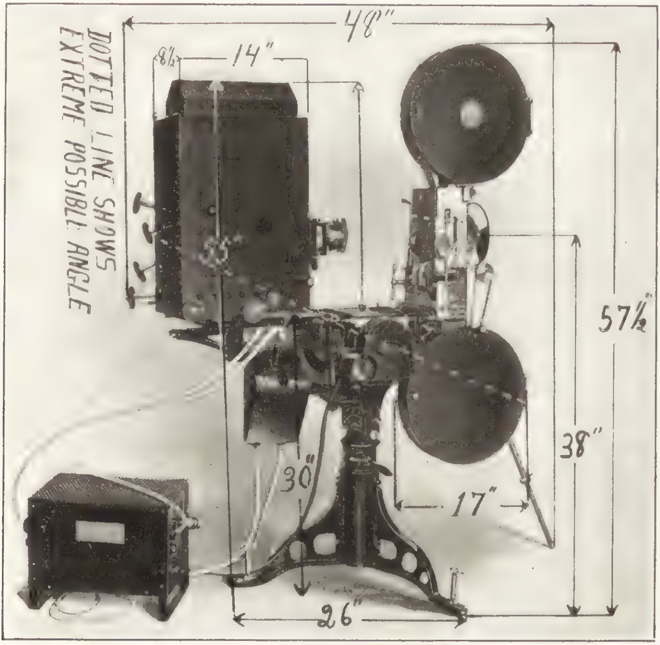


Figure 272.

attached to the nickel plated parts 372 (R and L), P. 2, by eight screws, the ends of which can be seen in nickel plated part.

No. 6.—Film Strips, 438, P. 2 (two of them), right and left, are the strips upon which the film slides, and which receive the pressure of the tension shoes. These strips are steel spring. Should they at any time show signs of wear they may be renewed by proceeding as follows: Follow Instructions Nos. 1, 2 and 5, and then take out the eight screws which hold the dark metal part, 382, P. 2, to the nickel plated parts, 372 (R and L), P. 2; slide out the film strips on that side and put in the new ones.

Caution: In putting in new film strips see to it that the nickel plated part clamps down tightly, so that there is no crack or space between the two. If there is it is likely that the edge of the film will wedge in this space and rip off a portion of

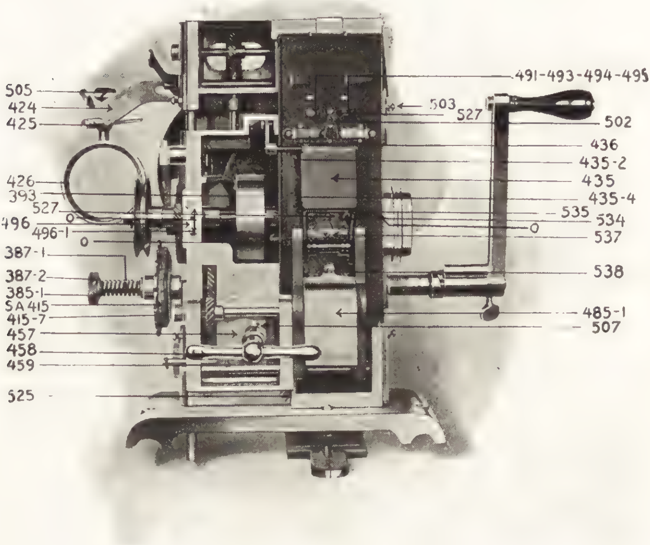


Plate 1, Figure 273.

its edge. Where film is injured in this way by a standard machine that is the place where the operator may look for the trouble. The process of reassembling the parts is but a reversal of their disassembling.

No. 7.—To Remove the Film Guiding Spool, 536, P. 2, follow Instruction Nos. 1, 2 and 5, and then drive out the taper pin in the steel collars in either end of spool spindle. These pins are taper and you will need a very fine punch to get them out. However, it is not likely that this particular operation will ever be necessary, as the collars are casehardened.

No. 8.—To Remove Aperture Plate, 439, P. 2, follow Instruction Nos. 1, 2 and 5. You can then take the plate loose by removing two screws at its top end.

No. 9.—To Remove Gear, 407, P. 2, first take off belt pulley

391, P. 2 (if it is on that shaft; it may be on the transmission spindle 377, P. 4), and then drive out the taper pin in the hub of gear, which releases the gear, though it may be necessary to remove cap 496-1, P. 1, and tap gently on the side of the gear to force it off, using a soft punch of course.

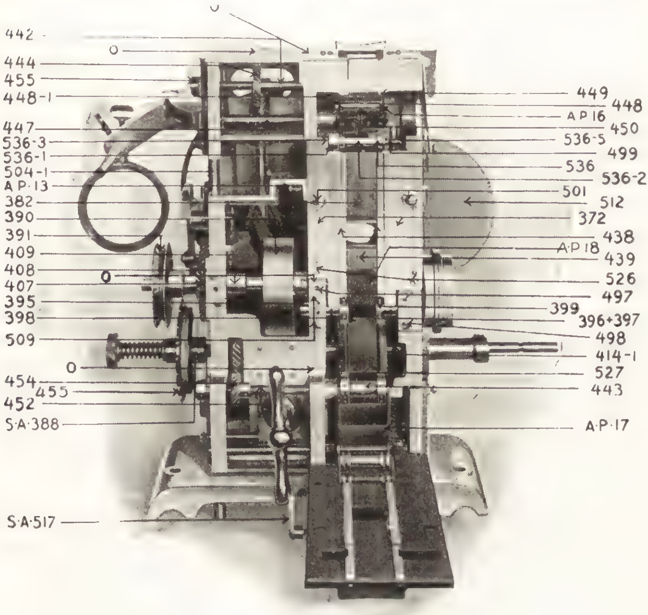


Plate 2, Figure 274.

No. 10.—To Remove Fly Wheel Shaft, 393, P. 1, first take off the oil well cover 389-1, P. 3. Next loosen set screw 392-3, P. 6. This screw is in the edge of the cam opposite screw 392-2, P. 6. You will need a small screwdriver, as it is countersunk into the cam. There are two of these screws, one on top of the other, the outer one acting as a lock to the inner one. Remove the outer one and then run your screwdriver down into the hole and loosen the inner one. After loosening the under screw, with the screwdriver still in the hole to hold the cam stationary, with the left hand revolve the fly wheel, at the same time pulling outward on the cam, and you will thus gradually work it off the shaft. Having done this, drive out

taper pin in the hub of fly wheel 390, P. 2, and loosen two set screws in collar 409, P. 2. You can then pull the fly wheel shaft out to the left.

No. 11.—To Remove Fly Wheel, 390, P. 2, follow Instruction No. 10, as it is also necessary to remove its shaft.

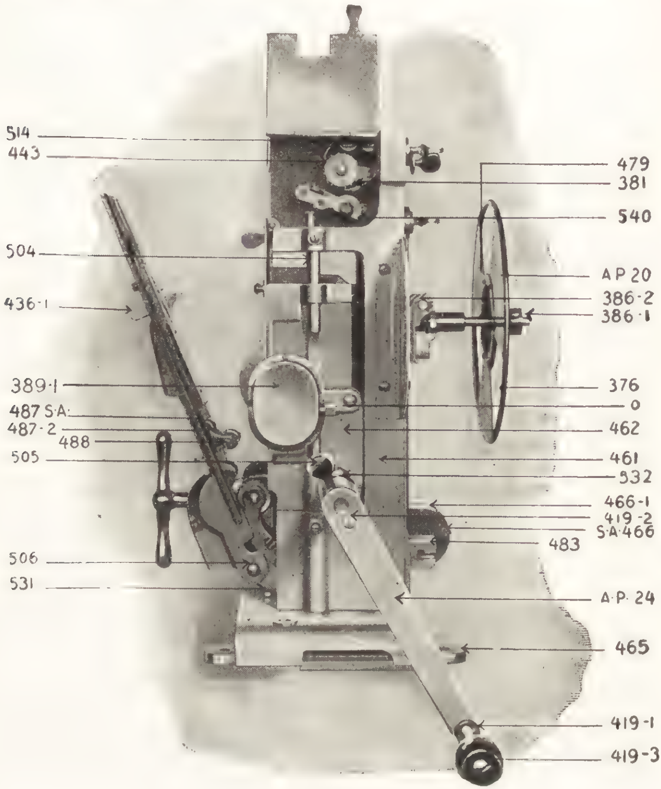


Plate 3, Figure 275.

No. 12.—To Remove Intermittent Sprocket, 399, P. 2, take off oil well cover, 389-1, P. 3. Remove set screw, 392-3, P. 6. (See Instruction No. 10 for details of removing cam.) Having removed cam 392, P. 6, drive the taper pin out of the hub of intermittent sprocket 399, P. 2, loosen the set screw in

collar 395, P. 2, whereupon you can pull star 394, P. 6, and its shaft out to the right.

Caution.—In replacing the intermittent sprocket or putting in a new one be sure to get the felt washer between the eccentric bushing and brass collar, and be sure to get the taper pin in hub of sprocket right end to. I would strongly advise managers and operators against attempting to fit a new intermittent sprocket to the old shaft. These parts are presumed to be standard, but the intermittent sprocket and star are literally the heart of the moving picture machine, and the variation of only so much as 1/1000 of an inch would be very perceptible on your screen. It would be much better and would cost but a few cents to send the star and shaft to the factory by parcel post and have a new sprocket fitted to the shaft when the old one wears out. See General Instruction No. 8.

No. 13.—**To Remove Eccentric Bushings** 396, 397 and 398, or either one of them, follow Instruction No. 12, and then loosen the screws in caps, 497, 498, P. 2, which will release the bushing. It may be necessary to tap the right hand cap lightly, since it may be stuck to the oil well casing by shellac which is used to make the joint between the frame and the oil well tight. At the right hand end of intermittent sprocket 399, P. 2, is a brass collar, 396, P. 2, which rests snugly against the end of eccentric bushing 397, P. 2. Between these two is a thin felt washer. This washer is for the purpose of preventing oil from leaking out of the oil well. In replacing oil well cover, clean the edges *thoroughly*, and smear edge of cover with thick shellac (to be had from any painter). After clamping cover on let stand a few hours before putting in oil.

Caution.—Don't put on *too* much shellac or it will squeeze out inside the well and may break off and injure the intermittent movement, as these small pieces are very hard.

No. 14.—**Adjusting the Intermittent.** See General Instruction No. 5. In order to accomplish this adjustment loosen cap screws 509, P. 2, and, using a punch set in the holes provided in eccentric bushings 397 and 398, P. 2, gently tap the bushings in such way that the side toward you will move in an upward direction. Be very sure and turn both these bushings the same amount, since otherwise you will raise one end of the shaft more than the other, thus not only throwing the star out of square with the cam, but throwing the work of pulling the film down on the teeth on one side of

the sprocket, which is very bad indeed, besides causing the shaft to bind in the bushings. *There is a scratch mark on each bushing and you must keep these two scratch marks in exact alignment with each other. In putting in a new set of bushings see to it that the thick part of the bushing rests against the cap—is toward you—and that the little holes drilled in the circumference of the bushing near one end comes next to the fly wheel, and not under the cap.* This will bring your bushing right.

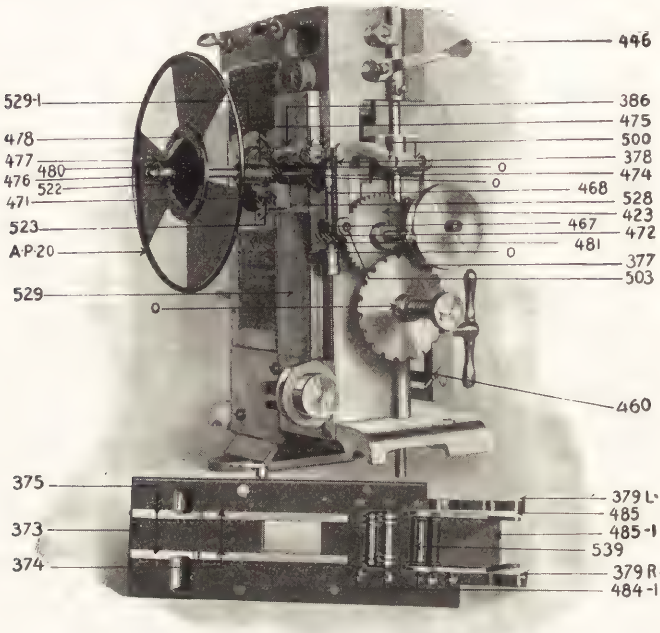


Plate 4, Figure 276.

No. 15.—To Remove Bushing, 408, P. 2, under cap 496, P. 1, follow Instruction No. 9 and remove cap 496, P. 1, by taking out the two screws in its face. You can then pull the bushing off and put in a new one.

No. 16.—The Framing Carriage is raised and lowered by means of eccentric 457 and sliding box 459, P. 1. The fram-

ing carriage is made to work tight or loose by means of screw 460, P. 4. These parts may be removed by first taking off framing handle 458, P. 1, then follow Instruction No. 23. When you get the front cover plate removed, pull out split key 530, P. 5, and remove screw 460, P. 4, whereupon you can pull out shaft 456-1, carrying the eccentric, from the front. This will also release sliding box 459, P. 1.

No. 17.—To Remove Revolving Shutter, A-P 20, P. 3, from its shaft simply loosen 522, P. 4, and pull it off the shaft. To remove the shutter and its shaft 386-1, P. 3, just pull outward, tapping gently with a hammer, if necessary. The shaft is simply stuck in and fitted with a taper joint, there being a key and keyway to give it the right circumferential location.

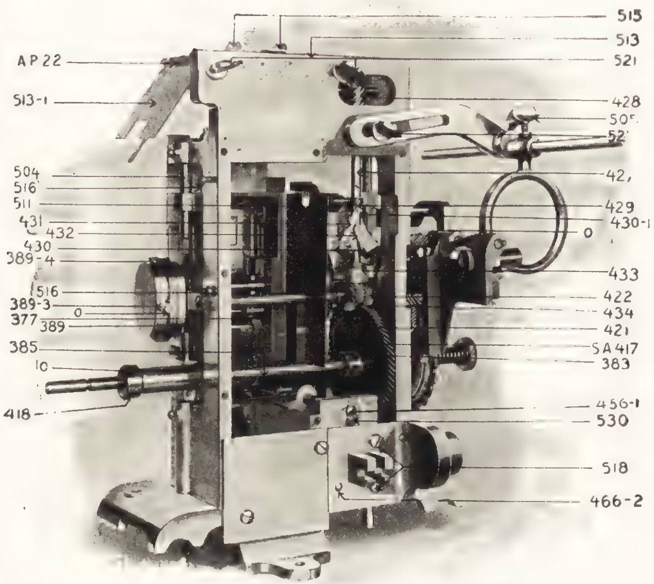


Plate 5, Figure 277.

No. 18.—To Remove the Shutter Blade 376, P. 3, and substitute another of different form, remove the six screws in outer rim 479, P. 3; take off the old blade and put on the new one, replacing the screws.

No. 19.—To Remove the Yoke Holder, 378, P. 4, take out screws 500, P. 4, and pull the casting off. In replacing this yoke be sure that the bearing surfaces are perfectly clean.

No. 20.—To Remove Yoke 467, P. 4, follow Instruction No. 20 and take out screw 503, P. 4.

No. 21.—To Remove the Casting, 386, P. 4, carrying the revolving shutter shaft, vertical shaft 468 and horizontal shaft 386-2, P. 4, first follow Instruction No. 20 and then remove screws (two of them) 528, P. 4. This releases the casting carrying the three shafts named, and the five gears mounted thereon.

Caution: In replacing this casting be sure that you get the washers just as they were, because there is likely to be a variation in the thickness of the two washers and if you get them switched you will have trouble with the gears binding.

The number of the casting with its assembled parts is A-P-10, including the three shafts named, and gears 475 (three of them), gear 474, and sliding gear 472, all on P. 4.

I would not advise the operator to attempt to replace any of these parts. If it becomes necessary to do anything to them, take the whole part off and send it to the factory by insured parcel post.

No. 22.—To Remove Front Plate Cover, 529, P. 4, first follow Instructions Nos. 19 and 21. Then take out seven small flat head screws on face of the cover, which releases the whole thing.

No. 23.—To Remove Crank Shaft, 385, P. 5, drive taper pin out of part 418, P. 5, follow Instruction No. 22, and then drive out the taper pin in the collar next the left side of the mechanism casting and the taper pin in the hub of gear S-A 417, P. 5. This releases the shaft, which may be pulled out to the right as you face the lens end of the machine.

No. 24.—To Remove Transmission Spindle, 377, P. 5, follow Instruction No. 23. Drive the taper pin out of gear 421 and 422, P. 5. Drive the taper pin out of the hub of gear 423, P. 4, which releases the shaft, and allows it to be driven out to the right as you face the lens end of the machine.

No. 25.—To Remove the Governor Lever, A-P 13, P. 2, it is only necessary to lower the framing carriage, stick a screwdriver from the right hand side and remove screw 511, P. 5.

No. 26.—To Remove Plate Covering the Top of the Ma-

chine, 513, P. 5, take out five flat head screws on the top of the plate and one on the lip which comes down in front.

No. 27.—To Remove Governor Vertical Shaft, 427, P. 5, follow Instructions Nos. 22 and 26, then drive out the taper pin in the hub of gear 434 and taper pin in collar 433. Drive out the straight pin 432, in the top of the governor weights 430, and the stop pin in the shaft just above the sliding collar, all in Plate 5. This will release the shaft, which can be lifted or driven out upward. This instruction applies equally to the removal of any one of the parts mounted on spindle 427, except the lower gear, which may be removed by merely following Instruction No. 23 and driving out the taper pin in its hub.

No. 28.—To Remove the Upper Sprocket, 443, P. 3, drive out the taper pin in its hub and pull sprocket off its shaft. The shaft may also be removed by driving out taper pin in gear 444, P. 2, having first removed the sprocket, of course.

No. 29.—To Remove Upper Sprocket Idler Shaft, 447, P. 2, take out the screw holding lever 446, P. 4, and slide the shaft out to the right.

No. 30.—Adjusting Sprocket Idlers. The distance of the two intermittent sprocket idlers 488, P. 3, from the sprocket is governed by screw 537, P. 1. When making this adjustment be sure that you set the lock nut on screw up tight. Part 485, P. 1, contains the two lower sprocket idler rollers 539, P. 4. The distance of these rollers from the sprocket is governed by screws 538. These idlers should be set as per General Instruction No. 12.

No. 31.—Tension. (See General Instruction No. 9). The tension may be altered by tightening or loosening screws (six of them) 494, P. 1.

No. 32.—Tension Shoes, 374, P. 4, may be removed by driving out the small taper pin in their lower end, and sliding the shoes out.

No. 33.—Tension is supplied to the take-up as follows: Part S-A 388, P. 2, is attached rigidly to shaft 385, P. 5. Chain sprocket wheel S-A 415 is mounted loosely on the same shaft with a cotton belting washer, 415-7, P. 1, between the two. These three parts are held together under pressure by springs, 387-1, P. 1, the tension of which is governed by thumbscrew, 385-1, this thumbscrew being locked in place on the shaft by screw 387-2. Setting this thumb screw inward, thus giving the springs more compression, has the effect of

increasing the pull on the take-up reel, and loosening it has the opposite effect.

Caution: It is necessary that washer 415-7, P. 1, be kept clean and dry. Don't allow oil from the chain to get on it or you will have trouble. To move screw 385-1 slack off on the screws on its face.

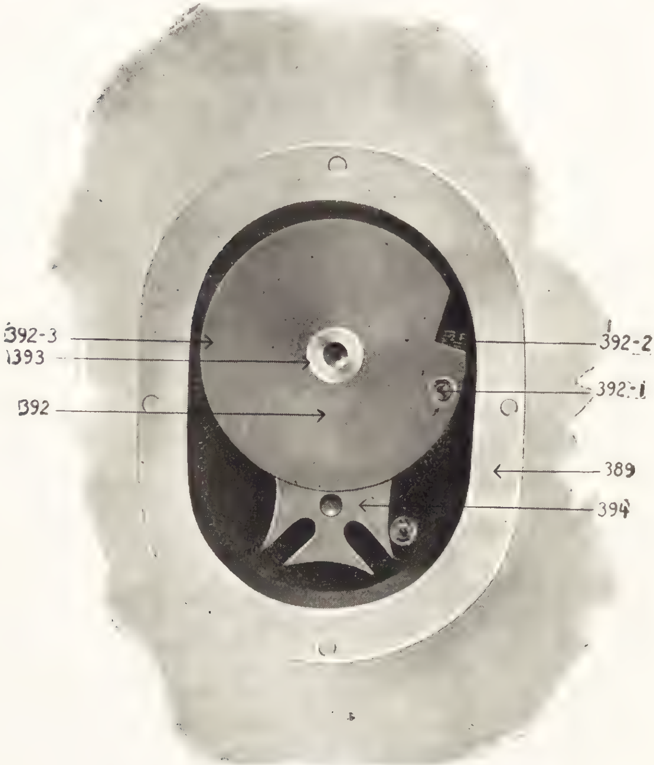


Plate 6, Figure 278.

No. 34.—Oil. (See General Instruction No. 1.)

No. 35.—Setting Shutter. (See General Instruction No. 18.)

No. 36.—Adjusting Intermittent. (See General Instruction No. 5.)

No. 37.—Clean Sprockets. (See General Instruction No. 3.)

NAMES AND NUMBERS OF PARTS FOR THE STANDARD MECHANISM, MASTER MODEL

Order Parts by Number Only. These Numbers Are the Manufacturer's Regular Stock Numbers. The First Column of Figures Indicates the Plate on Which the Part is Shown.

Plate No.	Part No.	Name.
2	—372	Sides for film slide, R. & L.
4	—373	Gate blank.
4	—374	Long tension strips, R. & L.
4	—375	Short tension strips, R. & L.
3	—376	Outside shutter blade.
5 & 4	—377	Transmission spindle.
4	—378	Yoke holder.
4	—379	Gate hinge, R. & L.
3	—381	Guide for threading machine.
2	—382	Film cradle.
5	—383	Oil guard.
5	—385	Driving spindle.
1	—385-1	Split nut.
4	—386	Shutter casting.
3	—386-1	Shutter shaft.
3	—386-2	Horizontal shutter shaft.
1	—387-1	Spring for takeup.
1	—387-2	Screw for split nut.
2	—388*	Friction washer.
5	—389	Inside oil box.
3	—389-1	Outside oil box.
5	—389-3	Oiler for oil box.
5	—389-4	Screws (4).
2	—390	Balance wheel.
2	—391	Motor pulley.
6	—392	Cam.
6	—392-1	Cam wheel driving pin.
6	—392-2	Set screw to hold pin.
6	—392-3	Set screws to hold cam to shaft (2).
6 & 1	—393	Cam shaft.
6	—394	Star.
2	—395	Set collar.
2	—396	Nut for 397.
2	—397	Bushing for 394 long.
6 & 2	—398	Bushing for 394 short.
2	—399	Intermittent sprocket
2	—407	Gear—14 teeth.
2	—408	Bronze bearing (under cap 496).
2	—409	Collar.
2	—414-1	Collar.
1	—415-7	Friction washer.
1	—415*	20-tooth chain sprocket complete.
5	—417*	70-tooth gear.
5	—418	Clutch collar.
3	—419-1	Wooden handle.
3	—419-2	Guide bushing.
3	—419-3	Handle screw.
3	— 24†	Crank complete.
5	—421	Gear—15 teeth.
5	—422	Gear—12 teeth.
4	—423	Gear—42 teeth.
1	—424	Stereo bracket.
1	—425	Stereo extension bar.
1	—426	Stereo single glass casting.
5	—427	Governor spindle.
5	—428	Sliding gear on governor.
5	—429	Governor head.
5	—430	Governor wings.
5	—430-1	Screws (4).
5	—431	Governor arms.
5	—432	Governor pin.
5	—433	Governor collar.
2	— 13†	Governor lever complete.
5	—434	Gear—8 teeth.
1	—435	Fire shutter.
1	—435-2	Fire shutter catch blank—R. & L.
1	—435-4	Screws for 436 (4).
1	—436	Gate latch slide.
3	—436-1	Gate latch.
2	— 18†	Film slide complete.
2	—438	Right and left film strips.
2	—439	Aperture plate.
2	— 17†	Film chute complete.
2	—442	Upper sprocket spindle.
2 & 3	—443	Upper and lower sprocket.
2	—444	Gear—20 teeth.
4	—446	Upper sprocket idler roller lever.
2	—447	Upper sprocket idler roller spindle.
2	—448	Upper sprocket idler roller bracket (left).
2	—448-1	Upper idler adjustment screw.
2	—449	Upper sprocket idler roller bracket (right).

Plate No.	Part No.	Name.
2	—450	Upper idler rollers.
2	— 16†	Upper idler complete.
2	—452	Lower sprocket spindle.
2	—454	Gear—16 teeth.
2	—455	Collar.
5	—456-1	Framing device spindle.
1	—457	Framing device eccentric.
1	—458	Framing device handle.
1	—459	Framing device sliding box.
4	—460	Adjustment screw for sliding box.
3	—461	Large frame.
3	—462	Sliding frame.
3	—465	Shoe to fasten lower magazine to head.
3	—466*	Knee and stud assembled.
3	—466-1	Knee to fasten arm for take-up.
4	—467	Yoke for outside shutter.
4	—468	Vertical shaft in 386.
4	—471	Bronze bearing for outside shutter.
4	—472	Sliding gear for outside shutter.
4	—474	Vertical gear—12 teeth.
4	—475	Gear—12 teeth, outside shutter (3).
4	—476	Bronze bushing, outside shutter.
4	—477	Bronze ring, outside shutter.
4	—478	Aluminum flange for outside shutter.
3	—479	Aluminum ring for outside shutter.
4	—480	Key for outside shutter.
	— 20†	Outside shutter complete.
	— 10†	Outside shutter casting complete.
4	—481	Key for sliding gear 472.
3	—483	Stud for telescope leg.
4	—484-1	Screws (7).
4	—485	Complete roller box.
1 & 4	—485-1	Roller box casting.
3	—487*	Idler bracket on gate, assembled.
3	—487-2	Idler bracket on gate.
3	—488	Rollers on idler bracket.
1	—491	Cup for tension spring on gate (6).
1	—493	Tension stud inside of 491 (6).
1	—494	Tension nut inside of 491 (6).
1	—495	Tension spring inside of 491 (6).
1	—496	Cap for cam spindle.
1	—496-1	Screws for 496 (2).
2	—497	Cap for intermittent movement.
2	—498	Cap for intermittent movement.
2	—499	Spring for guiding spool.
4	—500	Screws for 378 (2).
2	—501	Screws for gate latch (2).
1	—502	Spring on gate latch.
1 & 4	—503	Screws for sliding rods (4).
3	—504	Sliding rod—short.
2	—504-1	Sliding rod—long.
1	—505	Thumb screw for 424.
3	—506	Spindle holding gate.
1	—507	Screw for framing handle.
2	—509	Screws for 497 and 498 (4).
5	—511	Screw for governor lever.
2	—512	Light shield.
3	—514	Top rollers (2).
5	—513	Top plate.
5	—513-1	Flap for top plate.
5	— 22†	Top plate complete.
5	—515	Bracket for rollers in top plate (2).
5	—516	Screws to hold light shield (2).
5	—518	Screws (5).
2	—517*	Catch for fire shutter assembled.
5	—521	Thumb screw holding stereo bracket.
5	—521	Thumb screw holding magazines (4).
4	—522	Screw holding outside shutter to shaft.
4	—523	Screw holding 471.
1	—525	Screw for holding gate spindle.
2	—526	Screws for holding film slide (2).
1 & 2	—527	Screw for holding film slide and screw for 534 and 502 (3).
4	—528	Screws to hold outside shutter casting (2).
4	—529	Front plate.
4	—529-1	Lens ring.

Plate No.	Part No.	Name.
5	—530	Cotter pin for framing device spindle.
3	—531	Screws to fasten 465 to 461 (2).
	—532	Small set screw in handle.
1	—534	Tension spring for idler bracket.
1	—535	Pin for idler bracket.
2	—536	Guiding spool film slide—short.
2	—536-1	Guiding spool film slide—long.
2	—536-2	Space bushing for spool.
	—503	Screw to hold yoke holder to shutter casting.
2	—536-3	Guiding spool spindle.
1	—537	Set screw and nut.
1	—538	Set screw and nut.
4	—539	Rollers in roller box 485.
3	—540	Upper idler spring.
3 & 4	— 20†	Outside shutter complete.
3	— 24†	Crank complete.
	— 0	Oil holes.
	*S. A.	†A. P.

Edison Kinetoscope

Instructions for Model D

No. 1.—To Remove Framing Lever, 18047, P. 2, unscrew from head of the adjusting gear shaft.

No. 2.—Driving Crank, 18066, P. 1, is secured to the shaft by means of a spring catch. It is released merely by pressing on the spring and pulling outward.

No. 3.—To Remove Adjusting Gear Shaft, 18052, P. 1, and brackets 18057 and 18058, P. 1, remove screws (four of them) 17585, P. 1. The removal of these screws releases both brackets and the shaft. If it is desired still to further dissemble the parts, loosen collar set screws 2798, P. 1, whereupon you can pull the right hand bracket off the shaft together with collar 18055, P. 1. If it is desired also to remove the left hand bracket, 18058, P. 1, drive out pin in the hub of adjusting gear, 18049, P. 2, slip the gear off the shaft, and this releases the bracket.

No. 4.—To Remove the Gate, together with parts assembled thereon, pull out hinge rod, 18193, P. 2. If the hinge pin or gate sticks tap gently until released.

No. 5.—To Remove Aperture Plate, 19334, P. 1, remove screw 19346, P. 3, and another similar screw immediately opposite, which releases part 19320, P. 1. Next remove screws 20242, P. 1, pulling framing lever 18047, P. 2, down as far as it will go, in order to disclose the upper one of the screws. The removal of the four named screws releases the aperture plate, carrying with it part 19319 and film tracks 19318 and 19317 and guide rollers 19339, all shown on P. 1. The replacement of these parts is merely a reversal of the process

of their dissembling, but *be sure you set screws* 20242, *P.* 1, *in snugly, and that there is no dirt between the faces of the parts,* as these screws support the aperture plate.

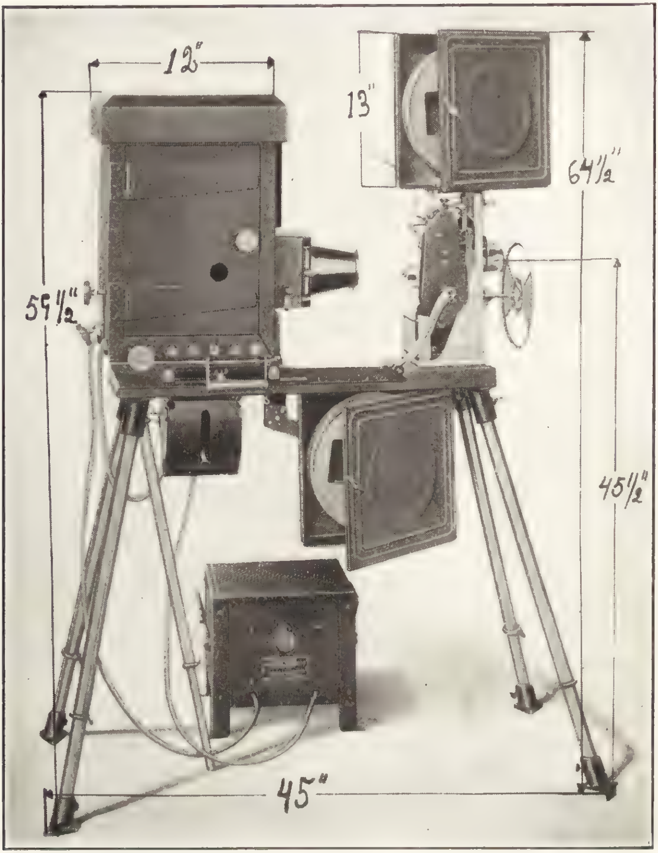


Figure 279.

In this connection let it be noted that the aperture is supported by a casting having its base just back of arrow head 38, P. 2. Should your aperture at any time get out of line

the first thing to do is make sure the screws holding this casting have not become loosened.

No. 6.—To Remove Film Guide Rollers, 19339, P. 1, follow Instruction No. 5 and then pull out the split key at the end of the spindle, which will release the parts. You cannot get the guide roller spindle out until you have released part 19320, P. 1, as per Instruction No. 5.

No. 7.—Film Tracks, 19317 and 19318, P. 1, are of spring steel, and are removable. When in the course of time they become worn it is only necessary to order new parts (they are right and left hand, as per numbers given on P. 1, therefore order the one you want *by number*). Remove screws (six of them) 19344, P. 1, lift off parts 19320 and 19319, P. 1, take out the old tracks and put in the new. They are notched to fit the screws, hence you cannot get them wrong, even if you try. Be careful and don't drop the small screws. A magnetized screwdriver is an excellent tool with which to handle small parts. See General Instruction No. 19.

No. 8.—To Remove Part 19325, P. 1, follow Instruction No. 5.

No. 9.—To Remove Upper Film Guide, 19321, P. 2, take out two screws, 20636, P. 2.

No. 10.—Gate Latch, 18758, P. 3, may be removed by taking out screws 18207 and 20406, P. 3. Screws 18207 and 18207 (one at the top and one at the bottom) serve to regulate the distance of the gate from the machine casting. They should be so set that the distance between the machine casting and the gate casting is the same at both sides of the gate. Unless the gate sets thus the tension shoes will exert unequal pressure on the film. Should it ever be necessary to move these screws be sure their lock nut is set up tightly when you have finished. If at any time the gate latch should fail to work right it is possible the small coil spring behind it has become too weak and needs stretching. This can easily be accomplished by removing the gate latch.

No. 11.—The Automatic Fire Shutter Governor may be removed by loosening screw 18779, P. 3, which is the small set screw in collar 18778, P. 3, on the outer end of its spindle, and set screw 8132, P. 3. Having done this you may slip spindle 19331, P. 3, carrying gear on its inner end out, which releases the fire shutter. The hub, which set screw 8132 holds to the shaft, and which contains screws (two of them) 18795, P. 3, is a part of the clutch disc which holds the governor weights. The governor cover, 18791, P. 3, may be

removed (having first followed the first part of this instruction) by taking out screws 8141 (two of them), P. 3. Having removed the governor from the gate you will see on the inner end of the hub in which was shaft 19331, P. 3, a brass

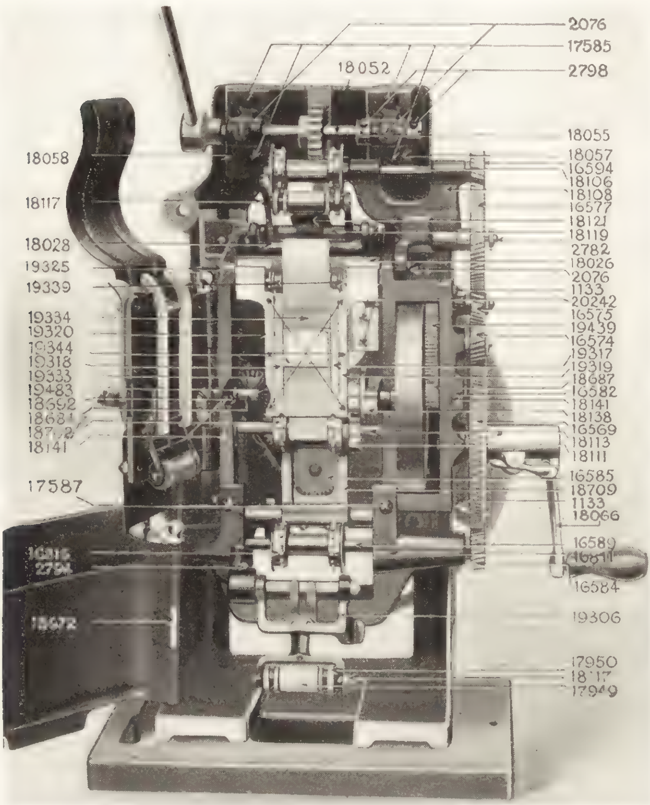


Plate 1, Figure 280.

collar. This collar is merely pressed on the hub, and is held there by friction alone. It may be pried off with a knife blade, or be removed with a pair of gas pliers. Having removed this collar, which is part 18785, you can lift off the shutter blade and

weight, thus revealing a spider-shaped copper spring. This spring is for the purpose of holding the shutter blade away from the revolving mechanism after the shutter is locked open, thus eliminating considerable friction which otherwise would be present. It will be noted that three of the prongs of the spring are bent upward and three are flattened out against the metal. This is as it should be, since the spring must provide friction between the revolving part and the shutter blade until the shutter blade has been raised. Do not bend the prongs, but leave them as you find them. This spring should be examined once in a while, since it will naturally develop some wear, which has the effect of allowing the metal revolving part to rub too hard against the shutter blade, thus causing undue friction. The governor may be still further dissembled by removing screws (two of them) 18795, P. 3, which are in the head of the nickel-plated hub of the clutch disc. These two screws have on their circumference small spiral springs, the part number of which is 18796. Be careful and do not lose these springs. Their use and purpose is as follows: When the semi-circular weights, which you will see when cover 18791, P. 3, is removed, spread open through centrifugal force, the part carrying the shutter blade is forced outward, toward the gate, against the pressure of these springs, by the two little arms or levers on their inner ends. This has the effect of locking the fire shutter open when the machine has attained speed, so that all friction is removed. When the speed drops below the danger point, these leaden weights fall inward, and the two little springs pull the central metal part, carrying the shutter blade inward again, thus unlocking the shutter blade and allowing it to fall and shut off the light from the film.

No. 12.—Bracket, 18780, P. 3, which supports outer end of governor spindle 19331, P. 3, is held by one screw and two dowel pins. Should you have occasion to remove the bracket be careful you don't bend the pins, or you will have trouble. Leave that particular bracket alone, is my advice.

No. 13.—Tension Shoes, 19324, P. 2, may be removed by taking out screws 19256, P. 3. These shoes are held against the film by two springs. These springs are held in place by screw 19498, P. 3, which also serve to provide greater or less tension. In other words they are the tension adjustment screws. By driving them inward the film tension is increased, and vice versa.

No. 14.—Gate Idler Roller, 17950, P. 2 (end), and 17949 (body), P. 2, may be removed by loosening the set screw in

17949, P. 2. Gate idler roller bracket, 18766, P. 2, and the spring which supplies tension to the bracket, may be removed by driving out shaft which holds it. To replace the spring which this shaft carries, place the spring in a straddling position over the center part of the roller bracket, with the two ends of the spring at the bottom, and the loop-shaped part on top. Place the spring in the groove in the casting and press the bracket and spring down simultaneously, pushing the shaft through the bracket and spring and into its bearing at the other end, while holding the spring and bracket down with the other hand.

In case the spring does not exert sufficient pressure, grasp the loop at the top with a pair of pliers and pull it outward. This will have the effect of making the spring stronger in its action. See to it that the coils of the spring are close to the central portion of the bracket.

No. 15.—The Shield covering the gears, P. 2, is removed by taking out screws 16580 and 16576, P. 2. *In replacing the shield, take notice that there are two washers on the inside of the shield,* and two on the outside, through which the screws pass. Be sure and get these washers in place or things won't "fit right."

No. 16.—Bracket, 18108, P. 1, carrying upper sprocket, 17992, P. 3, and its shaft and gear, 16594 and 18106, P. 1, may be removed from the machine by following Instruction No. 15, and then removing screws (two of them), 2076, P. 1.

No. 17.—Upper Sprocket, 17992, P. 3, may be removed from its shaft merely by loosening a set screw in its face. There is a set collar at the right hand inner end of the sprocket, designed to prevent end motion in the shaft and hold the sprocket in line with the film. Keep this collar set up against the casting snugly, but not tight enough to bind. You may remove top sprocket shaft 18106, P. 1, and gear 16594, P. 1, by loosening the set screw in the before-mentioned collar and the one in the hub of the sprocket, first having followed Instruction No. 15.

No. 18.—Main Driving Gear, 16569, P. 1, may be removed by following Instruction No. 2 and then removing screw and washer 17804 and 18079, P. 2.

No. 19.—Bridge Casting, 16582, P. 1, carrying gears 16575, 16574 and 16569, P. 1, may be removed by following Instruction No. 15, pulling off gears 16577 and 16575, P. 1; next removing screws (two of them, one at either end of the casting) 1133, P. 1, and carefully prying casting 16582 away.

No. 20.—Gear, 19574, P. 1, **is removed by following** Instructions Nos. 15 and 19, removing the screw in the end of the

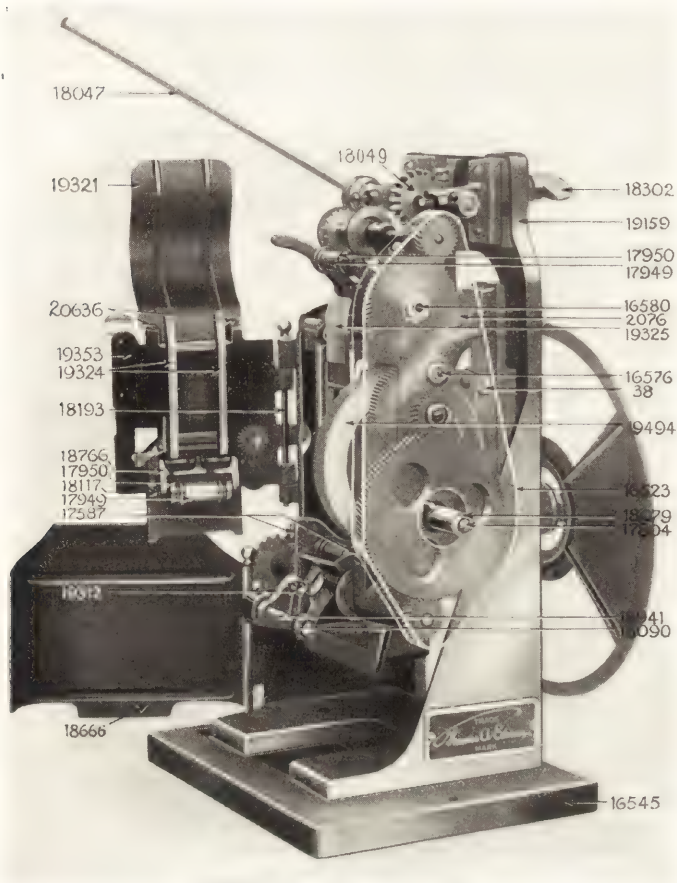


Plate 2, Figure 281.

gear hub and driving the shaft out. The shaft is **attached to gear 19439, P. 1.**

No. 21.—To Remove Fly Wheel Shaft, 18684, P. 1, **follow**

Instructions 15 and 19, then carefully, using a small steel punch, drive out the pin in cam 18138, P. 1, and in the hub of bevel gear 19483, P. 1. This releases the shaft and flywheel, which then may be pulled out to the right. The process of assembling is reversal of dissembling.

No. 22.—Right Hand Fly Wheel Shaft Bushing may be renewed by following Instructions No. 15 and 18, loosening set screw 18141, P. 1, and taking out the big, flat head screw which holds the bushing in place. The bushing may then be pulled out and a new one inserted in its place.

No. 23.—Left Hand Fly Wheel Shaft Bushing may be renewed by taking out the flat head screw which holds it and loosening set screw 18141, P. 1. The bushing may then be pulled out and a new one inserted.

No. 24.—Bevel Gear, 19483, P. 1, may be removed by first taking out the fly wheel and shaft (see Instruction No. 21). The gear may then be pulled off after driving out the pin in its hub.

No. 25.—Cam, 18138, P. 1, is removed by following Instruction No. 24 and then driving out the pin in its hub. It may then be slipped off its shaft.

No. 26.—The Lower Film Guard, 18709, P. 1, which comes up around the hub of intermittent sprocket 18702, P. 1, may be taken off by removing two screws at its lower end.

No. 27.—Intermittent Sprocket Shaft, 18113, P. 1, carrying the intermittent sprocket and star, may be removed by following Instruction No. 21, then loosening set screw, 18141, P. 1, and slipping out the left hand bushing. You can then take out the parts.

No. 28.—Renewing Intermittent Sprocket. *I advise that this be not attempted by the operator.* It is far better, from any and every point of view, to buy the star, sprocket and shaft assembled and ready to put in. In fact the owner will do well to have a spare star, sprocket and shaft assembled on hand, ready to put into his mechanism. See General Instruction No. 5.

No. 29.—Adjusting Intermittent Movement. Star 18111 and cam 18138, P. 1, will gradually develop lost motion, due to wear in the parts and in the bushings which carry their shafts. The lost motion thus produced may be eliminated by loosening set screw 18141, P. 1, and its mate which holds the bushing in the opposite end (also 18141, P. 1), and slightly revolving the bushings, *one to the right and one to the left.*

These bushings are eccentric, and this has the effect of raising or lowering the shaft, according to which way you turn the bushings.

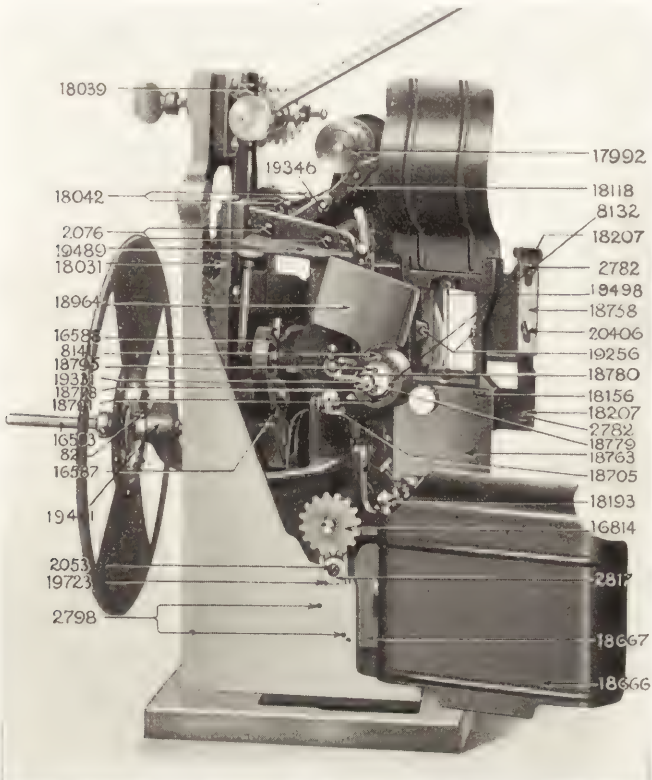


Plate 3, Figure 282.

Caution: Don't turn your screwdriver to the right (clockwise) with both bushings. If you do you will raise one end of the shaft and lower the other. A moment's consideration will show you the reason for this. The sprocket and star should be set just so you can feel the least bit of play in the intermittent sprocket. See General Instruction No. 13.

No. 30.—Lower Roller Bracket, 19306, P. 1, is removed by loosening screw 2794, P. 1. In putting the bracket back insert the shaft in the hole, and let the bracket lie on the sprocket as you tighten up screw 2794, *tight.* If at any time the tension on this bracket is not sufficient it is likely this screw has loosened and is allowing the shaft to revolve somewhat. Remedy: Tighten the screw.

No. 31.—Lower Roller Idler, 17949, P. 1 (body), and 17950, P. 1 (end), may be removed by loosening the tiny set screw in center of 17949 and slipping the shaft out.

No. 32.—Lower Sprocket Shaft, 16589, P. 1, may be slipped out to the right after you have followed Instruction No. 15, loosened set screws in the hub of lower sprocket and in the hub of chain sprocket 16814, P. 3. In replacing, slip the shaft in with the sprocket loose, and center it by closing idler roller bracket 19306, P. 1, so that roller, 17949, P. 1, fits between the flanges of the sprocket. Tighten up the set screw in the hub of the sprocket, with the sprocket in this position, and you will be all right.

No. 33.—Casting, 18611, P. 1, carrying lower sprocket shaft 16589, P. 1, the lower sprocket and its driving gear, together with chain gear 16814, P. 3, may be removed in its entirety by taking out screws 17587 (two of them), P. 1.

No. 34.—Revolving Shutter Shaft, 16593, P. 3, and gear, 16585, P. 1, may be removed by following Instruction No. 26 and loosening set screws 82, P. 3, in the holding collar, first having removed the revolving shutter. This will allow you to slip the shaft and gear out.

No. 35.—To Remove Gear, 19333, P. 1, and its shaft, proceed as follows: Follow Instruction No. 5, next follow Instruction No. 15, and No. 19 and No. 21.

No. 36.—To Remove Gear, 19333, P. 1, remove the two screws in the hub of gear 16588, P. 3. These screws are on the back end of the hub. Next pry off gear 16588, P. 3, and loosen the set screw holding the bushings. This set screw may be seen in the side of the casting just above the line leading to arrow head 18795, P. 3. Having loosened the set screw, carefully pry off the bushing toward the front, shoving the shaft and gear along with it. As soon as you have the bushing out of its bearing the gear and shaft can be pulled away.

No. 37.—To Remove Revolving Shutter Bracket, 19491, P. 3, first follow Instruction No. 15. Next follow Instruction No. 33. Remove four hexagon-headed large screws, one

of which is seen at 38, P. 2. This releases the entire mechanism from its supporting casting. Having proceeded thus far, you will find two heavy screws at the lower corners of the mechanism. Remove these and the brackets will be released from the mechanism.

No. 38.—**The Entire Mechanism,** that is to say, the part which frames up and down, may be removed from the frame by taking out the mechanism holding screws (four of them), one of which is shown at 38, P. 2, the three others being in corresponding positions, there being two on one side and two on the other. These four screws hold the mechanism to the frame.

No. 39.—**Setting the Revolving Shutter.** See General Instruction No. 18.

No. 40.—**Oiling.** See General Instruction No. 1. There is one oil tube, leading to the intermittent shutter gear bearings. The top of this tube is stopped by a steel ball in order to keep dirt out. Press the ball down with the nose of the oil can, and the oil will flow into the tube. A bit of cotton should be kept in the oil hole of gear 19333, P. 1, to keep out dirt. Beyond this no special instructions are necessary for the oiling of the Edison Model D, except that I would advise the use of a tolerably heavy lubricant on the star and cam.

No. 41.—**Lower Shield,** 18666, P. 3, may be removed, together with its hinge, by taking out two screws 2798, P. 3. Don't take out the hinge pin. If you do you are very likely to have a hard job getting the spring back into place.

No. 42.—**Adjusting Sprocket Idler Rollers.** See General Instruction No. 12, and Instruction No. 30.

No. 43.—**Cleaning Sprockets.** See General Instruction No. 3.

No. 44.—**Worn Sprocket Teeth.** See General Instruction No. 8.

No. 45.—**Worn Aperture Plate.** See General Instruction No. 11.

No. 46.—**Two-Wing vs Three-Wing Shutters.** See General Instruction No. 18.

No. 47.—**Adjusting Tension Springs.** See General Instruction No. 9.

No. 48.—**End Play in Intermittent Sprocket.** See General Instruction No. 7.

No. 49.—Deposit on Tension Springs. See General Instruction No. 10.

No. 50.—Lining the Sprockets. See General Instruction No. 4.

NAMES AND NUMBERS OF PARTS FOR THE EDISON MODEL D MECHANISM

Order Parts by Numbers. These Numbers Are the Manufacturer's Regular Stock Numbers.

Parts on Plate No. 1.

18058	Adj. gear shaft bracket (left).
18117	Upper sprocket tension roller shaft.
18028	Frame side post (short).
19334	Picture gauge, assembled.
19320	Film guide (left).
19344	Film guide screw.
19318	Film spacer (left).
19333	Revolving shutter driving shaft and mitre gear, assembled.
19483	Cam shaft mitre gear.
18692	Cam shaft bearings (short).
18684	Cam shaft.
18702	Intermittent sprocket.
18141	Bushing set screw.
16816	Take-up sprocket with flanges.
2794	Take-up roller bracket shaft set screw.
18672	Film protector hinge spring.
2076	Adj. gear bracket friction screws.
17585	Adjusting gear bracket screw.
2798	Adjusting gear shaft collar set screw.
18055	Adj. gear shaft collar.
18057	Adj. gear shaft bracket (right).
16594	Upper sprocket shaft pinion (helical).
18106	Upper steel sprocket shaft.
18108	Upper sprocket shaft bracket.
16577	Large intermediate gear (helical).
18121	Upper tension roller springs.
18119	Upper tension roller bracket pin.
2782	Gear guard screws.
18026	Frame side long post (drilled).
2076	Frame side post screw.
1133	Frame cap screws.
20242	Picture gauge screw.
16575	Second intermediate pinion (helical).
19439	Cam shaft driving gear.
16574	First intermediate pinion (helical).
19317	Film spacer (right).
19319	Film guide (right).
18687	Cam shaft pinion.
16582	Frame side cap.
18141	Bushing set screw.
18138	Cam and pin, assembled.
16569	Large driving gear (helical).
18113	Star shaft.
18111	Star.
16585	External revolving shutter shaft gear (helical).
18709	Lower Film guard.
18066	Driving crank long 7½ in.
16589	Take-up sprocket shaft.
16811	Take-up frame.
16584	Take-up sprocket shaft pinion (helical).
19306	Take-up tension roller bracket.
17950	Steel tension roller end.
18117	Tension roller shaft.
17949	Take-up steel tension roller body.
17587	Take-up attachment screw.

Parts on Plate No. 2.

18047	Adjusting lever.
19321	Film gate guard (upper).
20636	Film gate guard stop screw (upper).
19353	Film gate.
19324	Film tension bar.
18193	Film gate hinge rod.
19331	Drop shutter clutch shaft and mitre gear, assembled.

18766 Film gear tension roller bracket.
17950 Film gate steel tension roller end.
18117 Film gate tension roller shaft.
17949 Film gate steel tension roller body.
17587 Take-up attachment screws.
19312 Take-up tension roller bracket spring.
18666 Film protector.
18302 Upper film magazine thumb screws.
19159 Mechanism support.
17950 Upper steel tension roller end.
17949 Upper steel tension roller body.
16580 Large intermediate gear stud (helical).
2076 Frame side post screw.
19325 Upper film guard.
16576 Second intermediate pinion stud (helical).
38 Mechanism holding screws.
19494 Balance wheel and cam shaft pinion.
16523 Gear guard.
18079 Large driving gear stud washer.
17804 Large driving gear stud washer screw.
19410 External revolving shutter two-wing.
18941 Take-up steel tension roller bracket shaft.
18090 Second intermediate pinion cotter pin.
16545 Mechanism base.
18049 Adjusting gear.
18052 Adj. gear shaft.
19339 Upper film guard roller.
19325 Upper film guard.

Parts on Plate No. 3.

18039 Slide adj. rack.
18042 Slide adj. rack bracket screw.
2076 Frame side post screw.
19489 Frame side (left).
18031 Body side (left).
18964 Automatic drop shutter, weight and counter balance.
16588 External revolving shutter driving gear.
8141 Automatic drop shutter clutch cover screw.
18795 Automatic drop shutter clutch disc driving screw.
19331 Drop shutter clutch shaft and mitre gear, assembled.
18778 Automatic drop shutter clutch shaft collar.
18791 Automatic drop shutter clutch cover.
16593 External revolving shutter shaft with gear, assembled (helical).
82 External revolving shutter set screws.
16587 External revolving shutter intermediate gear (helical).
2053 Driving chain tension link screw.
19723 Driving chain tension link.
2798 Film protector hinge screw.
17992 Upper steel sprocket with flanges.
18118 Upper steel tension roller bracket.
18207 Film gate stop screw nut (upper).
2782 Film gate stop screws.
18758 Film gate latch and spring stud, assembled.
20406 Film gate latch screw, shouldered.
19256 Film tension bar screws.
18780 Automatic drop shutter bracket.
18156 Film gate guard screw, lower.
18207 Film gate stop screw nut.
2782 Film gate stop screws.
18779 Automatic drop shutter clutch shaft collar set screw.
18763 Film gate guard (lower).
18705 Star shaft bearing, eccentric.
18193 Film protector hinge rod.
16814 Driving chain upper sprocket for 9/32" shaft.
2817 Driving chain tension link screw washer.
18667 Film protector hinge.
18666 Film protector.
19346 Upper film guard pins.
19491 Ext. rev. shutter shaft and bracket and bushing, assembled.
18795 Automatic drop shutter clutch disc driving screw.
19498 Film tension bar spring screw.

Machine Take-Up

The take-up of a projector is an extremely important part of the mechanism, although until quite recently it seems to have received but little consideration from any one, except the projection department of the *Moving Picture World,* which has for several years been persistently advocating the invention and adoption of a take-up tension equalizer.

The old style take-up had grievous faults. Selecting the old style Edison take-up for the purpose of illustration, parts of which are shown in Fig. 283, it consists essentially of spindle 1 carried by bearing 4, the latter clamped in a cast-

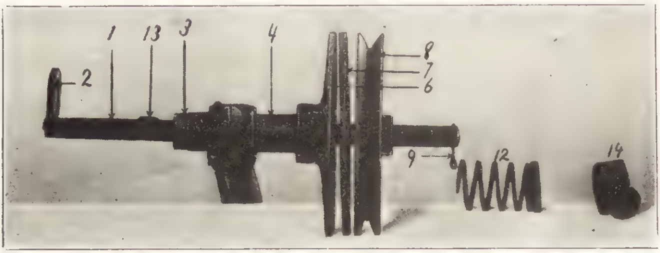


Figure 283.

ing attached to the mechanism, or in some machines by the lower magazine. Friction disc 6 was rigidly attached to spindle 1, and revolved therewith. Belt wheel 8 was mounted on shaft 1, upon which it revolved freely, using the shaft merely as an axle. Seven was a friction washer, usually made of fiber. The action was as follows: The reel was mounted on shaft 1, to which it was locked by dowel 13, the dowel engaging with the notch in the reel hub; the reel was prevented from slipping off the shaft by part 2. Spring 12 was placed on the shaft and compressed by collar 14, which was held in place by a thumb screw therein and by cotter pin 9. Now it requires but a moment's study of this assemblage to see that, since disc 6 is attached rigidly to shaft 1, whereas belt wheel 8 revolves freely thereon, when belt wheel 8 is driven, power will be imparted to shaft 1 through disc 6 exactly in proportion to the pressure with which the belt wheel is clamped against disc 6, or rather fibre washer 7, which, in turn, impinges on disc 6. All this is quite simple.

The whole trouble with the take-up proposition lies in the fact that, whereas the film is fed down through the projector and into the lower magazine at a uniform speed of approximately 60 feet per minute, and belt wheel 8 is necessarily driven at uniform speed, the film is wound on a reel the diameter of which is very small at the beginning, but constantly increases in size. Therefore it follows that in order to take up the 60 feet per minute fed to it the reel in the lower magazine must run very fast when the film roll is small, whereas after the film roll on the lower reel has become, say, 8 inches in diameter the reel must run very slowly, since the film roll is then more than 2 feet in circumference.

All the old style take-up did was to allow sufficient slippage between belt wheel 8 and disc 6 to a accomodate the before described condition. When the take-up first started to rewind there would be little or no slippage between these parts, but as the diameter of the film roll increased, slippage took place, which allowed the reel of the magazine to slow up, although belt wheel 8 continued to revolve at its regular

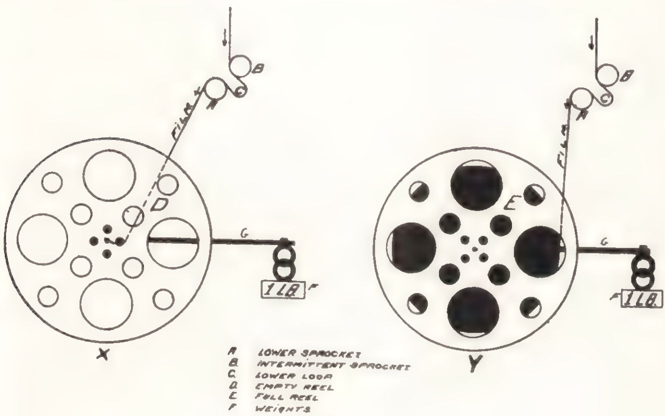


Figure 284.

speed. The objection to this is illustrated in Fig. 284. At X, Fig. 284, we see the film coming down from lower sprocket A and beginning to wind on the hub of empty reel D. The one-pound weight represents the pull of the take-up, which is constant throughout the run. At Y, Fig. 284, we see exactly the same thing, except that the film roll has increased to

about 8 inches in diameter. The pull on levers G (representing the pull of the take-up belt) being the same all the time, it requires no great discernment to understand that *the pull on the film at X will be a good many times that exerted at Y,* and this was the trouble with the old style take-up. Tension between 6, 7 and 8, Fig. 283, had to be sufficient to revolve the reel under conditions shown at Y, Fig. 284, or in other words, spring 12, Fig. 283, had to be compressed sufficiently to provide power to take up the entire reel of film, which meant that at the beginning, when the roll was small, the strain on the film was many times what it should be. This condition had a tendency to (a) cause losing of the lower loop; (b) exert unnecessary and injurious strain on the sprocket holes of the film, thus injuring the perforations; (c) it had a tendency to pull weak patches in two; (d) it had a very decided tendency to scratch the first fifty or hundred feet of film.

Of late, however, new and improved types of take-up have been invented, and are in operation on some of the later models of projectors. By their use these evils are either reduced or eliminated. See the various mechanism instructions.

THREADING THE MACHINE

All machines thread alike so far as the principle involved is concerned. In Fig. 285 the idea is clearly set forth. The film comes down from above, passes over the constantly running top sprocket, forms a loop, passes down from the aperture to intermittent sprocket, forms another loop, and passes over the lower, constantly running sprocket, and thence down into the lower magazine. The two loops must be long enough so that when the film moves down three-quarters of an inch it will not be stretched tight between the upper sprocket and aperture plate, but there will still be a loop left, and, conversely, the lower loop must be long enough so that during the time the film stands still over the aperture plate the lower sprocket will not pull the film tight between itself and the intermittent sprocket. This much is essential, but in practice the loops are carried considerably longer, or larger, the proportions shown in Fig. 285 being approximately correct. Fig. 285 shows the threading of the Power's Six machine.

The operator should thread his machine so that one picture or one title-space will be in frame over the aperture of the machine, in order that when the machine is started the picture or title will be "in frame" on the screen. To do this a small

electric light connected to the house supply may be arranged, so that it may be swung in front of the objective lens when threading, and moved out of the way when the job is finished.

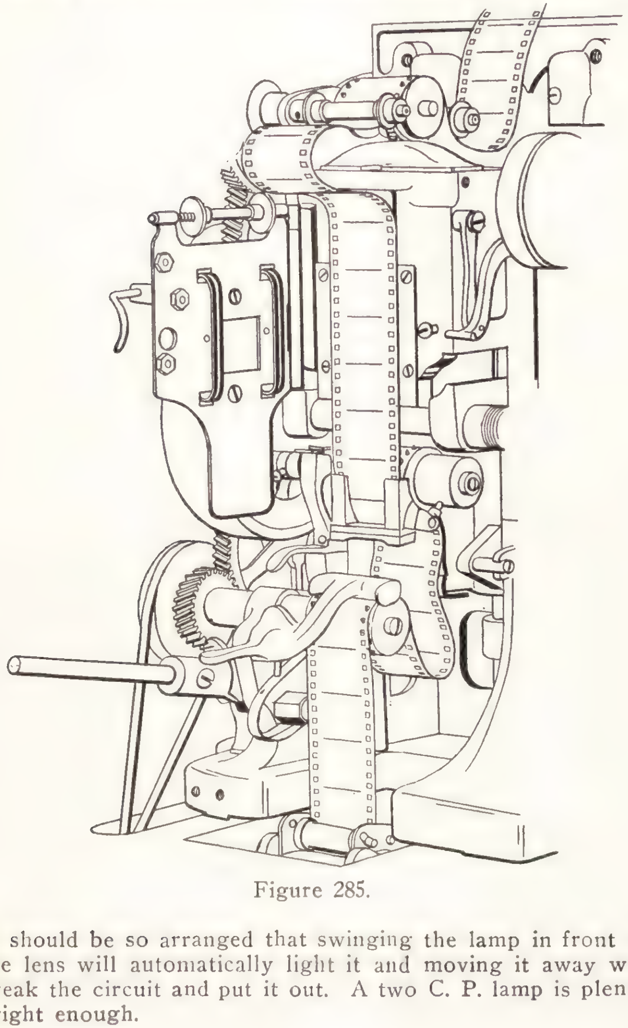


Figure 285.

It should be so arranged that swinging the lamp in front of the lens will automatically light it and moving it away will break the circuit and put it out. A two C. P. lamp is plenty bright enough.

Another method followed by some operators, and the one which really is best, is to fix a miniature battery lamp inside the mechanism, so that it is just below the back end of the objective lens. This lamp is connected to one or two dry cells, and as it burns only for a few seconds while threading, the cells will last for a long time. This plan, however, cannot be followed with all mechanisms, since with the Simplex, for instance, the light ray between the aperture and lens is entirely inclosed.

Still another plan is to notice where the dividing line comes with relation to the top of the aperture when the picture is in frame over the aperture, but this has the disadvantage that you cannot always see the dividing line. On the whole the light scheme is much the better.

NO MATTER WHAT PLAN IS ADOPTED, HOWEVER, THE PAINSTAKING, CAREFUL OPERATOR WILL NEVER START HIS PICTURE OUT OF FRAME. TO DO SO BRANDS HIM AS CARELESS AND, NO MATTER HOW YOU LOOK AT IT, CARELESSNESS SPELLS INCOMPETENCY.

FILM CONTAINERS

In many cities the law requires that film not in use on the machine shall be kept in fire proof steel containers.

B. Steinhauser, Terre Haute, Ind., is the inventor of the container shown in Fig. 286. This magazine is substantially made, and has the advantage of being in sections, each section independent of the other. The one shown in Fig. 286 is composed of three sections each entirely independent of the other. They are attached to the wall by means of lugs shown, and attached to each other by means of flat hooks on one side of each container which engages with a suitable receptacle on the other side. Under the film compartment is an opening designed to contain blotting paper moistened with water. The container sets at a slope so that the reel when placed in will immediately roll out again unless the door is closed, the latter being controlled by a plunger shown at the bottom of the magazine. Raise the plunger, and the door automatically opens and the reel rolls out. The advantage of this form consists in the fact that if a six reel program is used on two machines, three reels on each machine, three of the containers can be placed near one machine and three near the other, thus saving the operator steps. Also in case of fire the operator can grab the container by the handle shown at the top, lift it off the nail, and carry it outside instantly.

The "Safety First" Film Magazine, manufactured in Baltimore, Md., is an excellent operating room film container. It is cylindrical in form, its frame being made of cast iron, and its lower ends and compartment walls of sheet steel with one-half inch air spaces between each compartment at each end, and on the lower half.

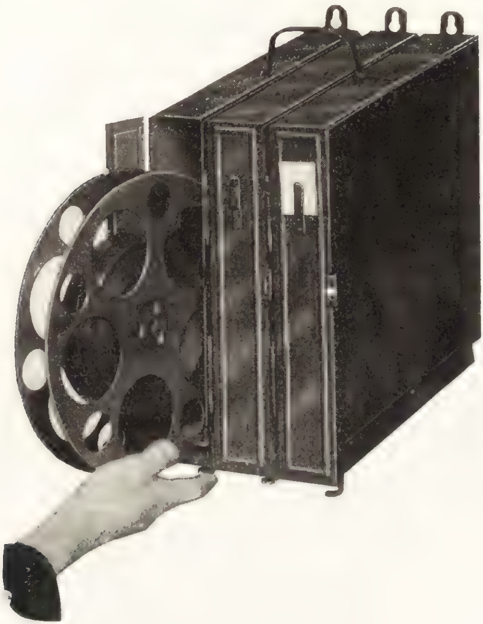


Figure 286.

The magazine is made to hold any number of reels desired. It occupies but little space, is claimed to be thoroughly fireproof and has many points to commend it. The cylindrical form prevents its being used as a catch-all for odds and ends.

In operation when the compartment doors are lifted a wire loop automatically raises a curved casting in the bottom of the compartment, thus automatically raising the reel half way out of the magazine.

The Spotlight

IT is no unusual thing for the operator to be called upon to operate a spotlight, similar to the one illustrated in Fig. 287. This device consists of a metal base and upright standards upon which are mounted the rheostat and switch. The upper end of this standard supports a lamphouse in such way as it may be swung or tilted to throw the light beam in any desired direction. Inside the lamphouse is an ordinary arc lamp, very similar to those used in moving picture projection machine lamphouses, but lacking the forward and backward screw adjustment. Spotlight rheostats usually are designed to deliver 12 to 15 amperes of current. In ordering a spotlight it is necessary that the voltage of your current and the approximate distance from the operating room to the stage be given, the latter in order that a proper lens may be selected. If direct current is used the upper carbon arm of the lamp must be connected to the positive wire.

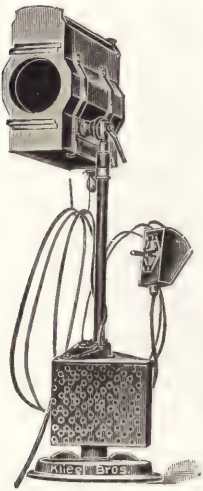


Figure 287.

The spotlight has a single plano-convex lens 6 inches in diameter, and the size of the spot at the stage is changed simply by pulling the lamp back or shoving it ahead. The spotlight may be used for a spot or for a flood covering the entire stage.

The spot should be round and free from ghost, but it will be found impossible to eliminate all the color from its outer edges. The shape of the spot as well as its freedom from ghost will depend very largely on how the carbons are set. They should be set practically the same as you would set them for a projection arc, varying the advancement of the upper carbon tip with relation to the lower, as well as the angle of the lamp itself, until the best possible results are obtained. It is better to use a half-inch cored carbon above and a three-eighth-inch below, if you can get them. Five-eighth carbons can be made to do, but are too large for the amperage ordinarily used on a spotlight. For alternating current, however, I believe two half-inch cored carbons will give the best results, though the amperage will have to be

boosted to fully 30 in order to approximate the D. C. spot. Following an actor with a spotlight is purely a matter of

Figure 288.

practice. There is nothing particularly difficult about it, the hard part being to get and maintain a clear round spot.

The hole in the operating room wall should be about 16 inches square, or 16 inches in diameter if round. A color-wheel may be obtained from any dealer in theatrical supplies, and is a very necessary adjunct to the spotlight. By combining the use of the spotlight with a dissolving stereopticon, using slides in the latter made from etched pattern glass and

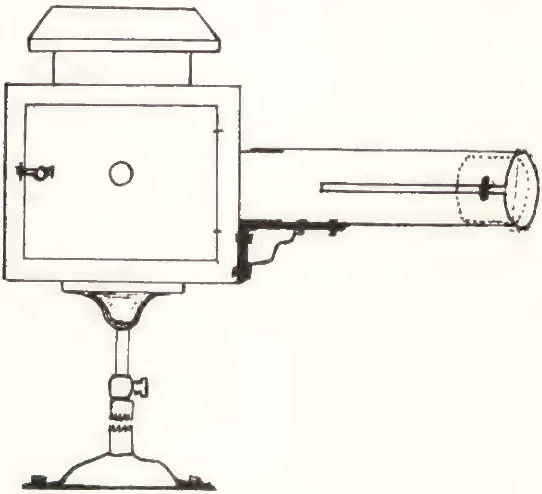


Figure 289.

rough glass such as is used in doors and windows, and carefully made metal slides producing a star effect or something of that sort, some very beautiful effects can be had by projecting with both stereopticon lamps and the spotlight at the same time.

Spotlight connection is usually made by using what is

known as "stage cable," a heavily insulated twin wire. These wires should be not less than No. 8.

Fig. 288 illustrates the optical system of a spotlight. The main difference in handling a spot with A. C. is that it is almost impossible to avoid a blue ghost at the top of the spot, or a double spot, the latter being due to the double crater.

It is possible to make a fairly satisfactory home-made spotlight by using an old projection machine lamphouse. You can fit up the standard the same as the one shown in Fig. 289, using any convenient floor base, and arranging to attach the lamphouse to the standard in such way that you can tilt it and swing it from side to side. The standard is made by having a hollow stem below, with a small one inside it which can be raised or lowered and clamped in place by means of a collar and set screw. Two pieces of different size gaspipe make an excellent standard. One must fit inside the other.

The Stereopticon

THE stereopticon consists of a lamphouse and lamp, a condenser, a slide carrier and an objective lens. The slides used in America measure 3¼ inches by 4 inches overall, with a mat opening 2¾ by 3 inches. In foreign countries the slides are for the most part square, though I do not remember the exact dimensions.

With moving pictures electric light forms the only satisfactory illuminant. With the stereopticon excellent results may be had by the use of ozo-carbi light, lime-light, or even with acetylene gas; this by reason of the fact that whereas in projecting moving pictures, using a modern mechanism, fully 50 per cent of the light is cut by the revolving shutter, and, moreover, there is a large loss of light at the spot, which must of necessity overlap the aperture by considerable, with the stereopticon practically all the light passing through the mat opening of the slide finds its way to the screen, and the only light loss by overlapping is a slight loss at the outer edge of the condensers where the light is weakest.

In moving picture projection the picture (film) is from one to two feet away from the condensing lens, whereas with the stereopticon the picture is right up as close as it can be got to the front surface of the condenser. With moving picture projection the objective is comparatively near the film, where-

as with the stereopticon it is a considerable distance (from 8 to 30 inches) away; incidentally, this is the reason why a cracked condenser lens will show in the stereopticon projection, whereas it will not show in the moving picture. In both cases it is the picture which is focused at the screen, and the condenser being so close to the picture in stereopticon projection, is focused at the screen therewith. Hence any imperfection like a crack will show.

In the old days, and still to some extent, the projection machine carried a stereopticon attachment, usually single, though sometimes dissolving. The single stereopticon attachment consists merely of an objective lens attached to the side of the moving picture mechanism, and an arrangement whereby the lamphouse may be shoved over to center the light ray from the condenser in the center of the stereopticon lens. This, however, brings about a complication, since if the same amperage used for moving picture projection be used for stereopticon projection, there is great likelihood of breaking the slides by reason of excessive heat. It therefore follows that, while slides which will only remain in the light five or six seconds may be projected with the heavy amperage used for moving picture projection without serious danger of breakage, if song slides, especially chorus slides, are to be projected, it will be necessary to reduce the current, else the slides will most likely crack. This may be accomplished in a number of ways, depending on whether the current is taken through a rheostat, a transformer, a motor generator set or a dissolver. If current is taken from power

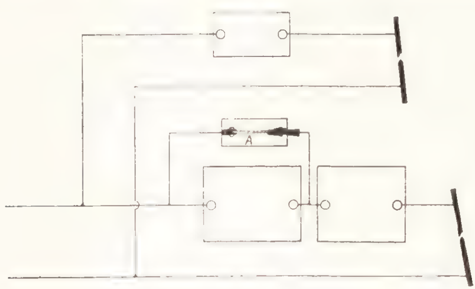


Figure 290.

lines through rheostats, then it is only necessary to connect in an additional resistance as per Fig. 290, in which A is a single-pole, single-throw switch. By opening this switch

the current is forced through the additional resistance, which should be of such amount that the current flow will be reduced to between 12 and 15 amperes, that being ample for stereopticon projection. If a transformer is used, then the current

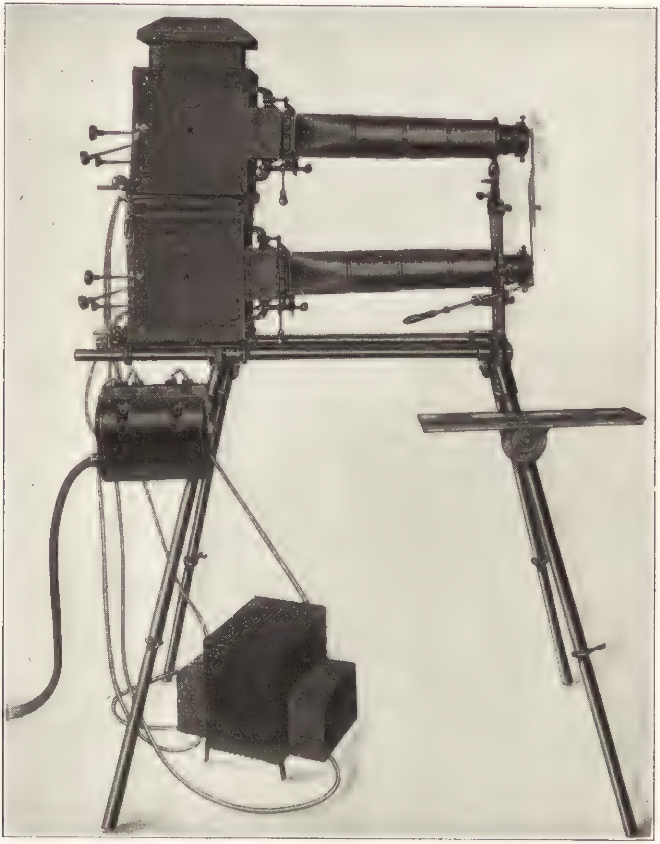


Figure 291.

may be sufficiently reduced by throwing in on the low notch, which with most transformers will give from 35 to 40 amperes A. C.; a little high, but it will do. If a motor generator set is used the thing can usually be done with the field

rheostat, or if that method is unsatisfactory, then a rheostat can be arranged so that the operator can cut it in circuit by means of a switch. With the later type mercury arc rectifier there is an arrangement for varying the amperage instantly, though it cannot be brought down low enough for stereopticon projection. The current may, however, be reduced by arranging resistance so it may be cut into circuit with the D. C. circuit of the rectifier.

In stereopticon projection one fundamental proposition is to *keep your slides clean.* When using a single stereopticon *don't* drop a slide into the carrier like you would throw a brick on a sidewalk, because if you do the picture being projected will jump around like a ship on a stormy ocean. With a properly matched lens system there is no earthly excuse for any shadow or discoloration of the light on the screen. The field should be absolutely clear, and the picture should be as steady as a rock during the entire projection.

It is not, however, my intention to go extensively into stereopticon projection with the single lamp, because there is little of that done nowadays. The modern method of projecting stereopticon slides is by means of a dissolver.

The Dissolver.—The dissolving stereopticon, Fig. 291, consists of two separate stereopticons mounted on one base, usually one above the other, with shutters in front of the lenses so joined that the opening of one shutter closes the other, and vice versa, thus gradually closing one lens and at the same time and in the same degree opening the other.

Each lamp should be connected to a source of separate electric supply, exactly the same as though the other lamp did not exist.

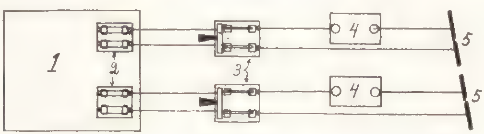


Figure 292.

Fig. 292 illustrates the method of connecting dissolver lamps; 1 is the main operating room switchboard and fuse cabinet; 2 are cut out blocks and fuses; 3-3 are the operating switches, one on each circuit; 4-4 are the rheostats, one on each circuit; 5-5 are the dissolver lamps.

When a machine-dissolver is used which utilizes the projection machine arc for the illuminant of the lower stereop-

ticon, a condition usually arises which requires special treatment. As a general proposition much higher amperage is required for the moving picture projection arc than is either necessary or desirable for use with a dissolver. Either the upper dissolver lamp must be supplied with amperage equal to the projection machine arc or else the projection machine arc amperage must be reduced, since high amperage on one dissolver lamp and low on the other would utterly ruin the effect on the screen. As has been said, under ordinary conditions, 15 amperes D. C. is ample for stereopticon projection. If amperage much in excess of this is used there is danger of excessive slide breakage, and this would be a very serious matter if the slides are fine hand-colored art slides such as those sometimes used by traveling lecturers.

Referring to Fig. 290, let us assume the upper rheostat to be of 15 ampere capacity and the lower 35. Under this condition the dissolving effect would be something of a joke, but by inserting sufficient additional resistance in series with the lower rheostat to cut the amperage down to an equal value to that delivered by the upper resistance (15), we thus secure an equal amperage at each lamp and the same screen brilliancy from both stereopticons.

It is possible to accomplish the desired result by means of an adjustable rheostat which will deliver 35 amperes maximum and 18 amperes minimum. This, however, is not the best way, principally because the rheostat would probably have to be built specially for the purpose, and that would be quite costly, since special apparatus usually is expensive. The more practical and effective way is to insert an additional rheostat, as indicated in Fig. 290, of such resistance that the two rheostats combined will equal the resistance of the upper rheostat, placing a single-pole, single-throw switch at A. It needs but a glance to show that when switch A is open the current must pass through both resistances, whereas closing switch A cuts the extra resistance out.

Where a combined machine and dissolver is used on A. C., taking current through an economizer, it is possible to operate both lamps of the dissolver from one economizer, though it is rather difficult to handle the light; also it is somewhat uncertain and requires practice. Unless handled skillfully the arcs will go out. This may be done in several ways, one of which is illustrated in Fig. 293, in which A is the economizer and B a double-throw, single-pole knife switch. When this switch is thrown over to the right the upper lamp is cut out, though its lower carbon arm is still "alive." When the

switch is thrown the opposite way the current must pass through both lamps. It is then necessary to freeze the

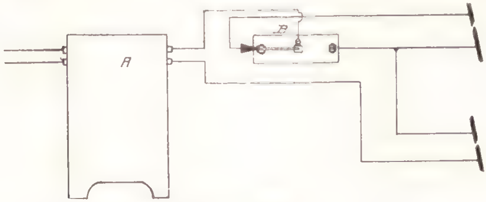


Figure 293.

carbons of one lamp while the arc is struck on the other, after which the carbons of the second lamp may be separated and the second arc struck.

This can be and is done, but, as I have said, it is difficult to handle the arcs, and unless one has had considerable practice there are likely to be times when the picture on the screen will suddenly vanish. The same thing might be done with rheostats, though there is ordinarily no reason for burning the arcs in series where current is taken through resistance. By the connection shown in Fig. 293 the resistance of the additional arc operates very materially to decrease the amperage.

Dissolver Shutter.—The dissolving shutter of a stereopticon is a very simple contrivance, and an efficient shutter may be made by any operator, though excellent dissolver shutters may now be had and are not very expensive either. The effect produced by them is, however, I think, not appreciably better than that produced by the well designed home-made article.

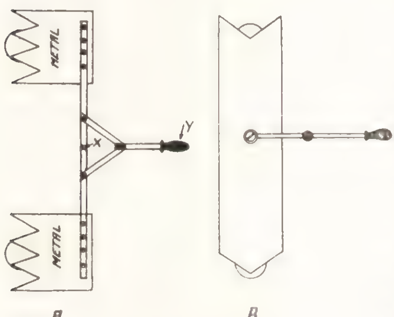


Figure 294.

In Fig. 294 we see two types of dissolving shutter, A being made of metal, and B either of metal or wood. The construction is so plainly shown that a description is hardly necessary. A consists of two pieces of sheet metal riveted to a bar (in which is hole X for

bolt upon which it swings) to which is also attached handle Y. The edges of the shutter are cut into saw-teeth two inches deep, and the shutter must swing far enough so that the light from one lens is entirely shut off when the other is open, and the shutter must be so located that when it is in the position shown approximately one-half of the light from each lens will be coming through. It is attached to the wall by bolt X so that it will swing in front of the lens. Shutter B may be made of lumber, asbestos board or metal. It is quite efficient. Its length must be such that when in the position shown one-half the light from each lens will pass through.

Many operators who have two machines with a stereopticon attachment on each work the dissolving effect by fixing a shutter somewhat after the fashion of half of shutter A, Fig. 294, in front of each lens and connecting the two by means of a bar or cord. It is the same thing exactly, only the lenses are about three feet to four feet apart, therefore the mechanical means of rigging the shutters have to be a little different. It may be accomplished by hanging the two shutters in grooves and connecting them by a cord running through pulleys on the ceiling, or in any other way that the ingenuity of the operator may suggest.

Dissolving Moving Picture.—In this connection many operators who run two machines dissolve one reel into the next by fixing a shutter arrangement similar to that suggested for separate, single stereopticons, also some operators connect their dowser handles by means of cords running to the ceiling, so that opening one closes the other. I only give the idea, since local conditions will call for different mechanical treatment and the operator who has not ingenuity enough to rig up things of this kind has no business in an operating room anyhow. I might add that there is a patent dissolving arrangement which utilizes this idea.

Color Wheel.—The stereopticon or dissolver may readily be fitted with home-made color wheels so that colored lights may be thrown on the stage or screen. All that is necessary is to take off one side of an old reel, leaving the hub attached to the other side. Place the two sides together so that the holes match, with the hub on the outside. With the two held together in this position drill four quarter-inch holes equidistant from each other, and a half-inch from the edge of the reels, these to receive small stove bolts. Cover three of the openings in the reel side with colored gelatine, say canary yellow, a light red, and any other suitable tint, leav-

ing one hole open through which to project the clear, white light or the slides. Clamp the sides, with the gelatine between, together with the bolts, and attach to the wall by means of a spindle, so that when the whole is revolved the openings will come successively in front of the lens. The open hole will allow the projection of the white light and the stereo picture as usual.

Matched Lenses.—It is absolutely necessary that the lenses of a dissolver be carefully matched, so that both lenses will project a picture of exactly the same size, when the two are working at a given distance from the screen; also they must be so set that the pictures projected by each lens will make perfect "register"—that is to say, occupy exactly the same space on the screen. To adjust the register of the lenses, first set the lower lens so that the picture occupies the proper position on the screen, and then adjust the upper lens to match. Do this with the light from both stereopticon lamps projected to the screen. One way to test the register of lenses is to make two metal slides that will fit snugly in the slide carrier. Now having clamped the two slides together punch four small nail holes, one in each corner, about where the corner of an ordinary standard slide would be. These holes must be drilled while the slides are clamped together or held together so that their edges are even all round.

Place one slide in the upper carrier and the other in the lower. Disconnect the dissolver shutter, open both lenses, and project the light from both lamps to the screen; adjust the lenses so that the light from the holes in the two slides register with each other. This same thing can, of course, be done by placing an ordinary stereopticon slide in the upper carrier, marking the edge of the picture on the screen and then placing the same slide in the lower carrier and making the lines match. But the same slide must be used, or two slides the mats of which are exactly matched and in exactly the same position in the slide. The metal slide scheme is the better one, because if you use two slides there might be a slight variation in their mats which would render the result of the test of no value. It might even cause you to reject two lenses which were really perfectly matched; also if you used one slide and it did not fit the carrier snugly it might not occupy exactly the same position in one carrier that it did in the other and that would render the test of no value. But with two metal slides which fit the

carrier, snugly, and with matched holes drilled you can depend upon the result.

Caution: When using drilled slides as above make a file mark on the top edge of both while they are clamped together and see to it that these marks are both up and toward the lens when the slides are in the carrier. If one of them is turned around the holes won't match.

It is essential that the slide carriers be so adjusted that the picture is level on the screen. This may be accomplished by raising or lowering one side of the carrier, blocking it in place with some non-inflammable substance, first being certain the dissolver, as a whole, sets perfectly level. The slide carrier should set as close to the condenser as you can get it. If your picture, which has been all right before, suddenly registers too far over one way or the other, it is likely the slide carrier has slipped endwise.

Patent Dissolving Carriers.—For use with single lamps there are a number of patent slide carriers on the market which either effect a very quick change of the slide or produces to some slight extent a dissolving effect. The best of these carriers I have seen is the "Ingento," made by a Chicago manufacturer. It is to be recommended for use with single lamps. It is well made, comes in wood or metal, and, rightly handled, produces an effect as nearly resembling dissolving as can be accomplished with a single lamp. It is for use with the single machine only, having no special value when used with a dissolver.

The Picture.—Given proper equipment there is ordinarily no excuse for anything but perfect stereopticon projection. Yellow corners in a stereo picture or a ghost in its center are merely evidence that the operator is too lazy properly to adjust his light or has not sufficient knowledge properly to match up his stereo lens system. The objective of the stereopticon, if more than 10 inches E. F., should always be what is commonly known as "half size."

Where a combined stereopticon and picture machine is used it will frequently be found necessary to move the lamp forward or back slightly with relation to the condensers when shoving over to the stereo picture. If this is not observed there will be dark corners in the picture.

The reason that a stereopticon lens to give a picture the same width as the moving picture at the same distance is of much longer focal length than the moving picture objective is that in one case the aperture (slide mat) is 3 inches wide, whereas in the other it is less than 1 inch in width.

Stereopticon Slides.—A stereopticon slide consists of two pieces of thin glass, 4 inches by 4¾ inches, bound together with gummed paper. Between these is placed a paper mask, called a mat, which serves the purpose of outlining the photograph.

On one of these glasses is a photographic emulsion, upon which has been printed a positive photograph 3¾ by 4 inches in size, which the paper mask has reduced to standard size, 3 by 2¾ inches. Mats, however, vary in size, that given merely being the standard article ordinarily used for advertising and song slides. The photograph may or may not be colored. If it is the coloring is done by applying water colors by hand to the photograph. The second glass is just a clear piece of thin glass, called a cover glass.

Figure 295.

Ordinarily there are some words, an ornamental design or decoration printed on one side of the mat, and this side of the mat is usually, though not always, red, white, gray or black. This is what is called the "mat side" of a slide, and it is the side which goes toward the light.

Fig. 295 shows the mat side of the slide. The other side of the slide is shown in Fig. 296. The slide must be placed in the carrier in an inverted position, with the mat side toward the light. If the other side is placed toward the light, then all reading matter thereon, such as signs on buildings, will read backward.

Handling Slides.—The first and cardinal law applying to stereopticon projection is *keep the slides clean.* The operator must remember that every fingermark, every spot of dust, oil, or anything else on the surface of a slide, will show on the screen, particularly if it happen to be on a clear space such as, for instance, a sky. How often I have sat in a theatre and watched the operator project what was or would have been a beautiful stereopticon picture, but on the surface of the slide was from one to half a dozen dirty, black

fingermarks. There is but one term which properly can be applied to this kind of work, and that is disgusting.

By all means keep your stereopticon slides clean. Unless you do the result on the screen will instantly brand you as a sloppy workman.

Slides may be cleaned by breathing on them while cold, polishing quickly afterward, or by washing with wood alcohol and polishing.

Another essential to good stereopticon projection is perfect steadiness of the picture on the screen. Providing the operating room floor be solid and the machine properly

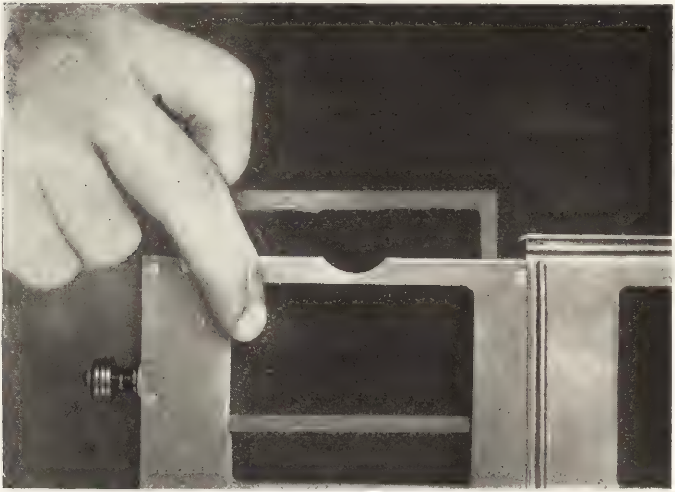


Figure 296.

anchored, there is ordinarily no lack of steadiness of the picture where a dissolver is used, but when using a single lamp, with a double slide carrier, many operators will move the carrier more or less in process of taking out and putting in a slide. This, of course, causes the slide in the other compartment of the carrier to move, and, as it is being projected at the time, it of course follows that the picture on the screen also moves. What a truly absurd effect is produced when one is watching, for instance, the projection of a picture of a city and, due to the ignorance or carelessness

of the operator, the city suddenly jumps up into the air a couple of feet and settles back with a slam!

When using a double carrier be very careful in removing and inserting slides. This, like many other things, is very easy of accomplishment if you know how. There is a right and a wrong way to do everything, even the putting in and taking out of slides. With the thumb and forefinger, grasp the slide by the upper corner nearest to you. Insert its lower edge gently into the carrier, and, as it drops down, catch it with the large finger of the same hand, holding the finger against the slide and the bar of the carrier, which will allow you to ease it down carefully into position without in the least jarring the carrier. The method of doing this is illustrated in Fig. 296. This has the additional advantage that in removing and inserting slides you don't get your fingers smeared all over their surface. The finger only touches the slide on the surface which is covered by the mat, hence if you learn to handle your slides this way there will be no fingermarks to show on the screen.

In Fig. 295 we see a picture of the mat side of an advertising slide. In the lower left-hand corner you will observe a black mark. This mark should be present in one corner or the other of all slides. It is designed to enable the operator to get his slides piled up and in the carrier correctly. In this instance the mat side of the slide is shown, which would go next to the light, and the mark, being on the lower left-hand corner, would be in the upper corner next to the operator as he puts the slides into the carrier. This mark may be a round dot, a star or a small paper label. The point is that it should always be in the same corner of all slides of any one set, so that in laying your slides out for use you merely pile them mat side up with the mark of all slides in the same relative position.

Caution: This cannot always be absolutely depended on, and should be checked up by the operator after piling the slides, since occasionally an error is made by the girls who bind the slides up, and one of the marks may be in the wrong corner.

There is absolutely no excuse whatever for an operator getting a slide in the carrier wrong side up.

Such a thing can only be the result of rank carelessness or inexperience. When running song slides the operator who knows his business proceeds as follows: On receipt of a set of song slides, he first cleans them thoroughly. He then lays them in order, mat side down, beginning with the title

and, 1, 2, 3, 4, 5, etc., until the chorus slide is reached, being sure that the spot-mark of all slides is in the same corner. He now turns the whole pile over and runs through them, glancing at scenes to check up the spot-mark, and to see that the tops of all slides are in the same position. He then lays the pile of slides on the machine table with the ***top*** of the scenes toward the *lamphouse.* In running them he picks each slide up by the right-hand corner nearest to him. He will thus be grasping the lower left-hand corner of the slide, which will be the upper right-hand corner as it goes into the carrier in an inverted position. In removing the slide from the carrier he will lay it down with what was the top edge of the slide, as it stood in the carrier, toward the lamphouse. Follow the directions through carefully and you will discover that he has simply turned the slide over in the process, and as he takes them out, one by one, and thus lays them down he will have their order exactly reversed in relation to the way they originally laid, so that the title will be on the bottom, and the top of the slide away from the lamphouse. Under these conditions, when a song is finished all you have to do is to turn the whole pile over and they are ready to run again.

The operator who follows these directions closely will never get a slide in bottom side up. In a short while the whole thing becomes a semi-automatic performance, and he would no more dream of picking up a slide and putting it in the carrier and taking it out and laying it down in any other way than as before indicated than he would think of putting a spoonful of food in his ear instead of his mouth.

In event a slide becomes cracked, it may be made as good as new if the crack is in the cover-glass—remembering that the cover-glass is always on the mat side of a slide. In that event all one has to do is remove the broken cover-glass and put in a perfectly clean, new one, rebinding the slide as it was before. If, however, the crack is in the photograph the damage is past remedying. Gummed slide binding tape may be had from any exchange, and should be a part of the equipment of every operating room.

Advertising Slides.—It is quite possible and practical to make slides designed to convey various messages to the audience, and many are the schemes which have been evolved for this purpose. The highest grade slides of this character are, of course, made by photography. The most satisfactory photographic slide is made by lettering a black card with white paint. Any size card from 6 by 8 inches up to 2 feet

wide will do. Any desired photograph may be attached to the card together with the lettering. The white paint is made of dry white lead and thin glue mixed thick enough to be easily applied but not thin enough to run. Being supplied with the advertising text matter any sign painter can make the card, or with practice even theatre managers may learn to do this fairly well, particularly if they secure books of architects' alphabets to use as a guide. A card should be printed in the proportions of 3¼ by 4 inches—that is to say, it may be any size, but in those proportions. Having finished the card, it is then photographed in the usual manner, and the positive print made, either by reduction or by contact if the negative is of slide size. In making up the card don't try to get too much reading matter in the allotted space, because the slide will only be projected for a few seconds, and if it is too long the audience will be unable to read it in full. Also too much ornamentation is a detriment, the plain slide being more pleasing and understandable than one containing an excess of "gingerbread." In making a slide it must be remembered that, whereas the slide itself is 3¼ or 4 inches the mat opening is only 2¾ by 3 inches, so that the positive print must include all lettering within a little less than these last named dimensions. Those who have made slidemaking a business say that for making the negative the regular slide plate is most satisfactory, and Defender, grade A, is pronounced excellent. For the development of the Defender, grade A, the following formula is given by Burton H. Allbee:

A:	Water	10 ounces
	Hydroquinone	75 grains
	Potassium metabisulphite	5 grains
	Potassium bromide	25 grains
B:	Water	10 ounces
	Sodium sulphite	1 ounce
	Caustic potash	50 grains

If a slide size negative is used, the slide positive should be printed by contact. It is recommended that the exposure be five seconds at a distance of 3 feet, using a sixteen-candle power carbon lamp. Development should be the same as for the negative.

If only one copy of a slide is desired, it may be made by writing on a white card with perfectly black ink, reversing the plate in the holder and stopping the lens down to make up for focus thrown out by reversal of the slide, and ex-

posing. The slide will then develop white letters on a black background and be ready for finishing, the same as a contact slide from negative. It is also possible to write on transparent celluloid with India ink and print by contact. This latter method has the advantage of saving expense of slide plate negative, and the celluloid costs very little and may be used over and over again, since the ink can be washed off. In general it may be said that black background slides are more pleasing than those with white backgrounds, since the glare from a white background is hard on the eyes, and makes the slide comparatively difficult to read. When a slide has been washed and fixed it should be set to dry, and should not be moved during the drying process, since moving it will cause uneven density.

Coloring.—When the positive print is finished it may be colored if desired, the operation being very simple. Velox water colors are perhaps best, and a single sheet will color many slides, therefore the cost is but slight. One stamp dissolved in two ounces of water will make about the right color strength, and once made it can be bottled up for future use. A number 10 brush is about right for everything except for very small letters. If the background of the slide is black the color may simply be flowed all over the letters and background. Red, yellow, and either green or purple are most satisfactory for printed slides, some letters being left white. Don't have all the color in one place as, for instance, red at the top, yellow in the middle, and green at the bottom. A more pleasing effect is had by dividing the colors up more, but experience in this matter is the best teacher. Flow the color over the letters, let it stay a moment, afterward removing the surplus water with a dry brush, and the letters will be evenly colored. If the shade is not dark enough repeat the operation until it is. After coloring don't wash the slide but set it to dry, turning it occasionally to maintain evenness of the coloring. After the coloring is completed the slide may be bound up in the usual way, being sure, however, to have your cover glasses clean on the inside.

There are also on the market a number of paints with which a slide cover glass may be coated, and when dry, any message it is desired to present to the audience may be written on this coating with a stylus or other blunt instrument. The effect is letters of light on an opaque background.

It is entirely practical to write on gelatine either with typewriter or India ink or by means of carbon paper, and if

properly done a reasonably sharp and fairly good slide is produced, though of course it does not compare with the photographic slide. In addition to this, colored inks are produced with which one can write on clear glass, using an ordinary pen. If carefully made, slides of this kind present a pleasing appearance, and they have the advantage of being cheaply and quickly made. "Glassine," made by the Thaddeus Davids Company, New York, is such an ink. It comes in several colors and is excellent.

Slide Coatings.—Dissolve dry gum dammar in turpentine and allow to stand until it settles. The proportion, by measure, is about one of dry dammar to twenty of turpentine. Very thin, yes, but it does the trick. To coat hold a clean cover glass level, pour on some solution, allowing it to spread over the entire surface. Then allow the surplus to drain back into the bottle from one corner, and stand the glass on end to dry. Glass treated thus may be written on with an ordinary pen and ink just as one would write on paper. It will require several hours to dry, but the writing may be washed off with turpentine and the coating used many times. It is difficult to tell which is the coated side. Therefore a small gummed sticker should be affixed in one corner or a permanent mark made with ink. Gelatine may also be used for coating, the process being as above, substituting for the dammar coating one made by dissolving in hot water clear gelatine, which can be had from any grocery or drug store, in proportion of one measure of gelatine to ten of water. This coating is fairly satisfactory, but can only be used once. The solution should be passed through filter paper before using, or at least be strained through very fine cloth.

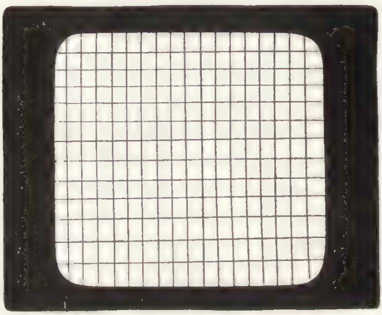


Figure 297.

Those making many slides of this kind will find the following a great help: Get a board, either basswood or clear, soft pine, of convenient size, say 12 inches square. On one surface paste a sheet of white paper, six or eight inches square, and on this paper paste an ordinary

slide mat, laying off the paper surface inside the mat checkerboard fashion with the lines about three-sixteenths of an inch apart both ways, as per Fig. 297. In practice lay the glass upon which you propose to write over the slide mat, fastening it in place with draughtsmen's thumb tacks (10 cents a box, at hardware or drug stores in small towns). The lines will serve as a guide for your writing and enable you to do a neat job. You may use black or colored inks. Clean glass, over which the tongue has been passed, may be written on after the saliva deposit has dried.

Comic or other newspaper pictures may be transferred to clean cover glass by laying a sheet of good heavy carbon paper face downward on the glass, the picture on top of the carbon paper, and tracing the outlines with a stylus or even with a smooth-pointed, rather hard lead pencil. If good carbon paper is used and the tracing neatly done the effect is not at all bad, though it is better if a dammar or gelatine coated glass be used. Colored gelatine paper may be used to tint such slides with good effect. Just bind the tint of gelatine you prefer between the drawing and a clean cover glass, using gummed binder strip to hold the glasses together. Even smoked glass may be employed for slides which are to be used only once, though the effect is seldom satisfactory, because it is almost impossible to write the text and get the glass into the slide carrier without marring the smoked surface. Just smoke the glass in a candle flame, or the flame of a match, and write in the smoke with any sharp-pointed instrument. A lead pencil will do very well. Newspaper pictures or text may be transferred to glass as follows: Coat one side of perfectly clean cover glass with coach varnish. Let stand until it is "tacky." Lay the matter to be transferred face down on varnish and rub with bowl of table spoon, from center out, until all air bubbles have disappeared. Let lay 24 hours, then soak in water *thoroughly* and carefully rub the paper off with the finger. The ink will remain.

A whole book could be written on stereopticon projection, but I do not feel justified in devoting more space to this subject, because of the fact that there is comparatively now but little stereopticon projection being done in moving picture theatres.

Operator's License

IN many localities theatre managers have opposed the license law, although it has been almost universally welcomed by operators. In fact, in many cases operators' unions have helped secure the passage of license laws. A license law, always provided it be drafted along the lines of common sense and the examination of operators be conducted by men who have at least a fair working knowledge of projection and the things allied thereto, is a good proposition, both from the managers' and operators' point of view. A license law rightly and properly carried out will have a decided tendency to eliminate the incompetent and to improve conditions in general. It is a mistake to suppose that a license law has the effect of curtailing the supply. Take Massachusetts, for example; there is a license law, backed up by a pretty stiff examination, yet, as a matter of fact, notwithstanding the stiff examination, there are operators far in excess of the demand in that state. However, according to the statement of Massachusetts' officials, whereas the license law has *not* operated to curtail the supply, it *has* operated to raise the efficiency of the operators very materially.

But even assuming that a good, stiff examination would tend to decrease the supply and raise salaries (not a fact, but merely an assumption for the sake of argument) it is a fact now quite generally accepted by the better class of managers that *cheapness in operators' salaries is not a good business proposition.* Very many high-class managers now thoroughly understand that it is quite possible to save one dollar in operator's salary and *lose three in box office receipts in the process.* The employment of incompetent operators, usually tolerated because they are cheap, acts not only to injure results on the screen and thus lessen the pleasure of the great mass of moving picture patrons, but it also adds an element of danger. In fact, the public in general have, largely by reason of scarehead newspaper articles, not only become aware of the highly inflammable nature of film, but have received a grossly exaggerated idea of the danger in moving picture theatres. Therefore, under this condition, the operator has become in a sense the guardian of the safety of his audience—a responsibility he ought thoroughly to realize, since, should he by any careless act ignite the film, while it is highly improbable that the resultant fire would in any way endanger life or even work the slightest

injury to any one of the audience, still might be the cause of a panic, and the result of a panic no man can forsee.

It is this danger which has brought about the licensing of operators, and the licensing power is vitally interested in the safety of the public, and, as a general proposition, examinations are largely conducted with the idea of ascertaining the competency of the operator from the fire-danger point of view only.

This, however, is an error, since the public is, and therefore the licensing power ought to be vitally interested in the competency of the operator from the *projection* point of view, since the competent operator can keep his machine adjusted and in such repair that there will be a minimum of movement in the picture upon the screen; he can keep his picture in sharp focus upon the screen, and he can fit his revolving shutter to meet the local conditions, thus reducing flicker to a minimum. And *all these various things have to do with eyestrain. Therefore, in the judgment of the author, the licensing authorities should see to it that the operator is not only a safe man from the fire standpoint, but that he is also competent from the projectional point of view.*

As a matter of fact, if the newspaper, instead of publishing ridiculous stories about fire danger would inform its readers that in the modern moving picture theatre the operating room is thoroughly fire-proof and that there is absolutely no danger whatever to the audience from a film fire in the operating room, the danger of panic (the only danger there is) would very soon be largely reduced. I make the broad statement that the newspapers themselves are largely responsible for the injury and death resulting from moving picture theatre fire panics.

I do not wish to be understood as intimating that the operator should not be thoroughly examined as to his ability as applied to fire-danger. Laying aside the danger to the audience, the operator is placed in charge of valuable property within the operating room, which may be damaged or entirely destroyed by fire. Therefore, from any and every point of view he should be a man thoroughly competent to handle operating room equipment.

I mention these things broadly, and might add that *even the operator who is thoroughly competent, so far as knowledge goes, may be thoroughly incompetent by reason of the fact that he is shiftless and lazy.* But the fact remains that the competent man can be compelled to do his work right, whereas the cheap,

incompetent man cannot be compelled to do his work right, because he doesn't know how.

The licensing of operators always tends to increase their efficiency because they must pass an examination, which compels them to study, at least to some extent, and the knowledge thus acquired they would not otherwise in all human probability possess.

The theatre manager who is a real manager will welcome anything which tends to raise the efficiency of operators, because it is upon that efficiency he must depend for results upon his screen. The real manager will even welcome increased efficiency at a higher price, and the other kind ought to be compelled, if necessary, to pay the price for excellence in projection.

The author of this book is heartily, thoroughly, and completely in accord with the examination and licensing of operators, but he suggests that the examining board which issues licenses be composed or partly composed of men who have at least a fair working knowledge of practical projection. *The fact that a man occupies a position as head of a city department is no proof that he is a competent examiner for moving picture operators, any more than he would be a competent examiner for locomotive engineers or sea captains.*

It is hard to say just what the make-up of the examiners' board should be, but as a general proposition, in the judgment of the author, the board should be composed of (a) one thoroughly competent, practical electrician; (b) the head of the building or fire inspection department; (c) one man *thoroughly* acquainted with *practical* projection and operating room practice—in other words, an operator.

It would be just as well to have the board composed of only one man, if the right man could be found, but he would have to be thoroughly versed in practical projection and operating room practice, a thorough electrician, and should have complete knowledge of the construction of operating rooms and their ventilation.

The best operators' examination of which I have personal knowledge is that conducted in Massachusetts by the Department of District Police, State House, Boston. For five years Mr. Harry Atkinson, State Building Inspector, had charge of examinations. Mr. Atkinson has made a close study of the points involved in practical projection, and is now, I believe, a thoroughly practical and absolutely competent examiner—I know of none more so. For some time, however, the examinations have been in charge of State

Building Inspector Ryan, who also is thoroughly versed on points pertaining to practical projection, including electrics, operating room construction, ventilation of the operating room, the mechanics of the projector, and the optical end of the projector, particularly as applied to the revolving shutter. Of late the New York City Board has been doing good work, under Chief Examiner Brown. These two boards are the best of which I have present personal knowledge.

The examination of operators should seek to determine (a) ability to measure wires and calculate their capacities; (b) extent of understanding of electrical action as applied to the ordinary multiple arc and three-wire system; (c) extent of knowledge of the principles involved in the transformers; (f) knowledge of motors and generators, particularly as applied to the care of the commutator bearings and the testing for electrical faults, such as grounded armature coils, loose joints in the magnetic circuit, this because more and more operators are being called upon to operate motor driven machines and motor generator sets; (g) knowledge of the principles involved in the mercury are rectifier; (h) knowledge of fusing; (i) knowledge of rheostat resistance and its application to the projection circuit; (j) the effect of overloading the wires; (k) knowledge of the various points in operating room construction and equipment, particularly with regard to the fuse system of the port fire shutter; (l) knowledge of the motion picture mechanism and of the arc lamp; (m) knowledge of film, including how to make a proper, straight, smooth splice, the effect of worn sprocket teeth on the film and on the projected picture, the effect of worn aperture plate and other worn parts of the mechanism on projection; (n) knowledge of optical principles involved in the revolving shutter of the mechanism, including the knowledge of how to make the projector shutter fit local conditions as nearly as possible, thus reducing flicker to a minimum, and such other things as may occur to the examiners, including the cause of damage to film in rewinding, and how to minimize its effect.

Up to date the worst trouble with the licensing proposition lies in the almost universal weakness of examining boards, and in many cases their total, *absolute incompetency.* It savors of highway robbery to compel an operator to pay a fee for a license where the examination is nothing more or less than a farce, yet I am obliged to say that—from the evidence in hand—this is the situation in some of the smaller cities, as well as in a number of the larger ones.

Rough Draft of License Law.—It would be impractical to include a model operators' license law in this book, because of the difficulty in framing a law which in all its details would be applicable to varying local conditions. The fundamental principles of such a law, however, would be the same in any locality, and it is these fundamental principles I propose to incorporate, leaving the suggested details to be worked out to fit individual local needs.

(1) Designate places in which it shall be illegal to display motion picture films until the projecting apparatus and the operating room have been approved and duly licensed. Forbid the use of oxyhydrogen gas or limelight for motion picture projection. Name the licensing power and give it authority to make regulations and to enforce them.

(2) Provide for an examination for operator's license. Specify briefly the qualifications necessary to obtain such license. Require that the applicant for license shall have a certain amount of experience, either as an operator or operator's assistant to be eligible for an examination. Establish minimum age of an operator (twenty-one years).

(3) Provide for the licensing of persons to act as assistants to operators, and designate what work in the operating room they may and what they *shall not do.* Minimum age to be one year less than for operator.

(4) Provide for fees to be paid for the licensing of machine, operating room, operator and assistant operator, also for annual renewal of the two last mentioned licenses, and fee for the same.

(5) Provide penalties for violation of any provision of law or regulation of the licensing authority.

In addition to these general provisions I would suggest that the law governing operating rooms should make provision for (a) their thorough ventilation; (b) a vent flue sufficiently large to carry away all fumes and smoke in case of film fire and to contain an electric fan of ample dimensions; (c) a fire shutter fusible link system along the lines suggested on Page 223; (d) that placing conduit on the floor should be forbidden; (e) that the operating room construction should be such that its walls will be thoroughly fire-proof, and that brick, hollow tile, or concrete be required where its use is practical; (f) that the operating room feed wires be large enough to carry the combined current capacity of all apparatus in the operating room, regardless of whether it i ever all used at one time or not; (g) that it be required tha the wiring be so done that the operator will in case of nee

be able instantly to switch on a portion of the house lights; (h) that a metal receptacle for hot carbon butts be required; (i) that all film rewinding and repairing be done either inside the operating room or in a fire-proof room immediately adjoining and connecting thereto; (j) that proper fire-proof metal receptacles be required for films, and that it be required that all film not in actual use or in process of repair or rewinding be at all times kept in these receptacles; (k) that metal lining of operating rooms be forbidden; (l) that the projection machine be thoroughly grounded to the metal lining or framework of the operating room, if there is such; (m) that the keeping of oils, alcohol or highly inflammable substances in quantities of more than two ounces each be forbidden; (n) that no exposed inflammable material be allowed inside the operating room, except a work bench of two-inch hard-wood lumber, and such other regulations as may seem advisable.

Operator's Report

ONE of the things which would very largely tend to remedy the matter of poor inspection in exchanges would be an operator's report blank, which theatres ought to have printed and require their operators to make out, *the same to be forwarded to the manager of the exchange with the weekly check.* These reports should *not* be sent in with the films, thus falling into the hands of subordinates and probably either disregarded or destroyed. *The manager of the exchange is the man who should get them.* If reports such as these are made out and retained, when the theatre manager comes to send in his check he is in position to comment intelligently upon the condition of the service.

With this end in view I submit what I believe to be a fairly good blank form for this purpose.

A blank of this kind not only will enable the manager to check up on the condition of his service, but will also place the exchange manager in position to check up the work of his inspection department. If it is found that the films are chronically in bad condition. then these reports should be sent directly to the head office of the General Film, the Universal, Mutual or whatever the service is, with the suggestion that an inquiry be made of the exchange manager as to the reason for the condition of his films.

When a film is received in bad condition it is well to send in the inspection tag. if one there be, together with the opera-

tor's report. This enables the exchange manager to fix the blame directly on the inspector responsible.

OPERATOR'S REPORT.

No. ..... Date ....

Condition of Film Received from ....

Reel No. ....

Name of Subject ....

Leader ....

Title ....

End ....

Irregular Splices and Out of Frames ....

Loose Patches ....

Breaks in Film When Received ....

Rewound before Shipped Away ....

General Condition .... Remarks ....

.... Operator.

Note.—Operator is required to fill out this blank completely, making one copy to be retained in the operating room, the original to be delivered to the theatre manager.

Figure 298.

Theatre Heating and Ventilating

HEATING and ventilating a theatre involves a considerable number of distinct and from some points of view entirely different problems. To go into the matter of heating and ventilating theatres with anything like completeness would not only consume a vast amount of space, but would necessarily involve many pages of highly technical text, and there seems to be no way of avoiding the use of technicalities in dealing with a matter of this kind. Not only is this true, but unless one literally made a complete book on the subject I do not believe the layman could be taught to apply the rules for figuring air pressure and resistance in inches and all that sort of thing with any degree of accuracy or success.

I shall therefore confine my remarks on these two topics largely to such things as readily can be grasped and understood by the average man. To go further than that is, I think, not advisable.

With regard to ventilation, there are, in general, two distinct problems: First, how much ought there to be; second, which is the better method of heating for the various parts of the building, direct or indirect? The first thing to do is *ascertain whether or not there is a local law on the subject of theatre ventilation*, and if there is what are its requirements. The provisions of local law must, of course, be complied with, but if these provisions are insufficient to provide for the comfort of the audience, then it will be better to go beyond the local requirements and provide such ventilation as will secure the comfort of the audience.

In this connection, however, it should be understood that *an atmospheric condition which may be entirely healthful is not necessarily such as will produce comfort.* Healthful condition merely means the supplying of sufficient fresh air to keep the vitiated atmosphere inside the theatre above a certain degree of impurity. It should also be understood that air will become impure with a greater degree of rapidity in summer time than in winter. This is by reason of the fact that whereas in the winter the air is only laden with the

vitiating poisons contained in the exhalations from the lungs and a comparatively small amount arising from the body, in summer the latter is very largely increased by the rapid evaporation from the pores of the skin and bodily heat. Ventilation not only includes the bringing in of fresh air and the expulsion of an equal amount of foul air, but also, rightly considered, includes the control of moisture.

Briefly, the feeling of comfort or coolness is largely if not wholly a matter of the rapidity with which evaporation from the pores of the skin takes place. The more rapid the evaporation from the exposed surfaces of the human body, the more comfortable will the individual feel, and as before stated, it does not follow that because one feels comfortable the atmospheric conditions are necessarily healthful—they may be far from that. Therefore ventilation, as such, involves the separate and distinct problems of supplying healthful conditions and comfort.

It is very generally conceded that, provided the outside atmosphere be itself reasonably clean and healthful, *the supplying of from twenty to thirty cubic feet of fresh air per minute per person is sufficient to produce reasonably healthful conditions,* and certainly is sufficient to avoid any distress in breathing. The actual necessary quality of fresh air is to a considerable extent dependent upon the method by which it is delivered into the room. In the larger theatres the expensive but ideal practice is coming more and more into use of delivering the intake of fresh air through properly located ducts underneath the floor, which connect with small mushroom ventilators located under each alternate or each third or fourth seat, both in the auditorium and in the balcony. This method of distributing the intake assures a thorough and even mixture of the fresh air with the foul, and where it is employed it is not necessary to supply air in such large volume as is required where it is brought in through one, two, or three or four large openings. The latter does not secure a complete mixture of the fresh and the foul air in all portions of the house; therefore it is necessary to supply a larger quantity. Briefly speaking, I think we may say that from fifteen to twenty cubic feet of air per person per minute will be entirely adequate where the mushroom system of ventilation is used, and from twenty-five to thirty-five will answer where the air is brought in through from one to four large openings.

The methods employed for ventilation are many, but the fan system is the only one upon which dependence may be

placed for positive results. There are those who ventilate by means of in-lets located either at the floor or six feet above it and depend for the exhaust on one or more large registers in the ceiling, connecting with pipes passing through the roof and terminating in a swinging cowl hood.

This method is not to be recommended. It is at best but a makeshift. There is nothing positive in its action, and if the temperature within and without be equal there will be but very little fresh air brought into the auditorium.

The fan system, on the other hand, delivers a certain definite quantity of air into the auditorium, and this, of course, forces out an equal quantity of foul air, hence when we use the fan system we know precisely how often the air will be changed every minute.

There are those who advocate the changing of the atmosphere in the auditorium a certain given number of times per hour. This, however, does not seem to me to spell common sense, because in one theatre where the cubic contents are great as compared to the number of seats, it might supply an unnecessarily large quantity of fresh air, whereas in another theatre where the ceiling is low and the cubic contents are very small, as compared with the number of seats, it might fail to supply an adequate amount of air to keep the auditorium in healthful condition. It seems to me that the supplying of a certain number of cubic feet per minute per seat is the only proper basis to work from.

Wall and Ceiling Fans.—It will be clearly understood that what is known as "wall fans" and "ceiling fans" have nothing whatever to do with ventilation, as such. These fans are, however, quite necessary, and serve two distinct purposes. First, as before said, anything which causes rapid evaporation from the pores of the skin will produce a feeling of comfort. Now the mere supplying of fresh air at the rate of even thirty cubic feet per minute per person may not secure comfort to the patron, because if it is brought in through mushroom ventilators it will practically not produce any draught whatever, but simply produce a healthful condition, so in order to produce a rapid circulation and movement of the air we install wall and ceiling fans, and the circulation of the air by these fans causes rapid evaporation from the pores of the skin, and therefore brings about a feeling of comfort, and thus we have the healthful condition through the forcing in of fresh air, and through the stirring of it up by the wall and ceiling fans we get comfort.

Very careful planning, judgment and care should be

exercised in the location of wall fans. They should not blow directly on the audience, but should be set on shelves about six or seven feet from the floor, and set to blow straight outward, pointing in the direction which will assist rather than retard the movement of air through the room. Ceiling fans may, of course, be located anywhere that is deemed advisable, since they blow straight down and do not ordinarily produce a strong current of air.

In this connection, it is much better to have comparatively large wall fans running at slow speed, than to have small fans running at high speed. They are cheaper of operation and make less noise, modified by the fact that too large a wall fan would create too heavy an air current in one direction. What has been said of exhaust fans applies equally to wall fans. We may, however, consider 18 inches as the extreme diameter advisable to use. All fans must, of course, have intelligent care and attention. They should and must be oiled at stated periods. The bearings of electric fans have an oil well. This does not mean that they will run forever without a refilling of the wells. The oil wells should be thoroughly cleaned out and filled with fresh oil once a week in summer. There should be stated times to do this, and it should be done at that time, otherwise it will in all human probability be neglected, and this neglect will mean cut journals and trouble. The commutators of fans should be examined occasionally and both the bars and bushes kept in good condition. A good scheme with fan commutators is to let well enough alone. That is to say, if the commutator is running nicely, don't fool with it. If it is sparking badly, however, remove the brush to see if the contact is good, or to see if the commutator itself is black and dirty, or roughened, in which case, carefully clean it with double O sandpaper. Never use emery paper on a commutator, since it contains particles of steel and iron, and you will simply aggravate the trouble by smoothing it up with emery paper. The principal thing with a fan is to have regular set times for examining, oiling and cleaning them, and to exercise good sense in caring for them. See "Care of the Commutator," Page 372.

Another important office of the wall fan is the prevention of pockets of foul air. This is a matter which should be carefully studied by the architect who plans theatres; also by the theatre manager himself. Underneath the balcony and in corners there is always the liability of pools of stagnant air, which become heavily laden with impurities, often to such

extent as to be positively poisonous and dangerous. These pockets easily may be avoided by the judicious use of wall or ceiling fans.

Where the air is forced in through large openings, the common and best practice permits the location of the in-lets to be about six feet above the floor, and the location of the out-lets to be in or near the ceiling. This plan, however, has the objection that if the air which is driven in is passed over heating coils, or is for any other reason warmer than the air inside, it immediately rises and passes out through the ceiling ventilators *without distributing the beds of foul air next the floor* which the audience is continuously breathing. This bed of air next the floor, being cooler than the incoming air, will remain at the bottom. On the other hand, there is serious objection to air being driven in through large floor radiators by reason of the fact that more or less unpleasant and even dangerous draughts are thus created. Where this latter plan is used the speed of the air through floor radiators should never exceed two hundred feet per minute.

It will be seen from the foregoing that, as between locating the ducts above the floor level and bringing the air in through large floor radiators or radiators located in the side wall at the floor line it is a choice of two evils. Neither one can by any stretch of the imagination be called ideal.

The better method and in fact the only really efficient method of theatre ventilation is the establishment of a chamber, preferably underneath the main floor of the auditorium near the stage end, or if there be a stage, then preferably underneath the stage. The air should be pumped into this chamber by a fan of proper design and capacity. The chamber itself should be divided by two partitions of ordinary chicken wire stretched tightly and properly supported. These two wires should be located about three feet apart, and upon the side next the intake should be stretched sheets made of cheesecloth. The air will thus be compelled to pass through the two thicknesses of cloth, which intercept a large portion of the dust. This will not only render it more healthful, but will reduce the bills for cleaning and redecorating. Back of these sheets should be the heating coils, steam heat being the most desirable for theatres, in that it is reasonably easy to manage, reasonably cheap in installation, and in the event that the plant should lie idle in cold weather there is nothing to freeze up but the boiler. The chamber containing the coils should be stopped at its inner end by a shutter system, and at one side there should be a by-pass, also controlled by

shutters, so that by manipulating these shutters or dampers the temperature of the air may be regulated. If it is too hot ease up on the hot chamber damper and open up a little on the by-pass, thus allowing cold air to mix with the warm. It is also possible, though rather expensive, in summer time to place cakes of ice in this chamber and thus cool the air as it is forced in.

In operating the air filter its area must be eight or ten times the sectional area of the in-let from the fan; also the cloth filter sheets must be removed at intervals for cleaning and must be thoroughly dried before again being used. If they are not thoroughly dried then the dust blowing through will form a paste and stop up the openings in the cloth.

It is only intended to give ideas broadly in this article. It is not my purpose to go into the matter deeply, but merely to tell you or give you an idea of how the thing can be done, leaving the individual to work out the details.

For small theatres of the storeroom variety such an elaborate plant would not be practical. I believe the ventilation of such theatres may be best accomplished by forcing air in by means of a suitable fan, located in an opening at one end of the theatre, preferably the curtain end. To be effective the movement of air must be fairly rapid. Remember that in summer the air pumped into the room will be almost if not quite as warm as that already inside. *It must, therefore, depend for its cooling effect entirely upon the evaporation produced by rapid movement.* Bear in mind the fact that anything which produces evaporation lowers temperature. You may be very warm, yet, let a fan blow air into your face, and although it is the same air, just exactly as warm as it was before, still you feel decidedly cooler. Why? Because the moving air is producing rapid evaporation. Drop alcohol on the back of your hand, and although the liquid be of even temperature with the surrounding atmosphere, it feels quite cold. This is because it evaporates rapidly, hence lowers the temperature of the skin at the point of contact. This being true, it naturally follows if the air be driven through the room fast enough to cause evaporation of perspiration it will not only keep the air within the theatre pure but will also produce a sensation of coolness. This cannot be carried to the point of producing a strong draught, since that would be highly dangerous in the production of pneumonia or at least "bad colds." This plan, taking everything into consideration, is, I think, the best for storeroom theatres, though it will require fans of ample dimensions during hot summer weather.

The air may be cooled by blowing it over cakes of ice, or through a maze of cold water pipes. This is effective, but costly, unless there is an unlimited supply of cold water available at very low cost.

It is also a fact that three or four large cakes of ice located at a convenient point in the auditorium will radiate a surprising amount of cool air for quite a distance, and, moreover, the sight of the ice has a certain amount of auto-suggestive effect on the audience.

Where a new theatre is under construction it is always advisable to consult a sanitary engineer with regard to the ventilation of the auditorium. It is a subject of too much importance to be in other than thoroughly competent hands.

Ventilating Toilet Room.—*Toilet rooms should invariably be ventilated by suction. In other words, the fan should pull the air out of the toilet room. Never, under any conditions, ventilate a toilet room by forcing air in.* The reasons for this I think are too obvious to require discussion.

In this connection, let it be clearly understood that when it comes to moving air, the volume of movement will depend largely upon the fan area. This seems a simple statement, but when you come to think of it, it really means that every increase in diameter is effective by four times, thus: A 36-inch exhaust fan will remove four times the amount of air that an 18-inch fan will move, both running at the same speed. It follows that the larger fan is very much better adapted to use in theatres from more viewpoints than one. It will move a vastly greater amount of air at a very much lower speed than will its smaller diametered brother. It will be found as cheap, or cheaper, in first cost, to install one large exhaust fan than two small ones of equal combined capacity. It will be found that one large will move a cubic yard of air cheaper than will two smaller ones, and that the upkeep cost of one large fan will be less than that of two small ones of equal combined capacity—provided that the large and small fans be of equal excellence in mechanical and electrical construction.

Don't buy cheap fans. It costs more in the first outlay—considerably more—to get good fans, but *it pays in the long run,* both in money and in the saving of temper. A cheap fan is not only ineffective, but its up-keep is usually very expensive; also its useful life is short. Still worse than all this, however, is the fact that it is a continual source of annoyance, because there is usually something wrong with it about half the time, and it is generally out of commission when most needed.

A great many sets of rules are given for figuring the necessary

capacity of fans to change the air in rooms of various dimensions in a given time.

I shall give you one of these rules which I have selected as the best, but you must understand that it is only approximate, and cannot be wholly relied upon, since very much will depend on the kind and type of fan used, as well as its position, and whether it has free delivery or delivers through a pipe or duct.

In figuring the necessary size of fan to use, you must first determine th number of minutes in which the air in a given room must be changed, which is found according to the following formula: The constant in this instance is 30 cubic feet

$$\frac{\text{Length} \times \text{Width} \times \text{Height}}{\text{Seating capacity} \times \text{Constant}}$$

of air per person per minute for the moving picture theatre. For instance, supposing we have a room 25 feet wide by 80 feet long, with an 18 foot ceiling, seating capacity 200, the problem would be as follows:

$$\frac{25 \times 80 \times 18}{200 \times 30} = \frac{36{,}000}{6{,}000} = 6$$

We therefore, find that six minutes is the time in which it would be necessary to change the air in such a moving picture theatre room in order to serve the purposes of healthful ven-

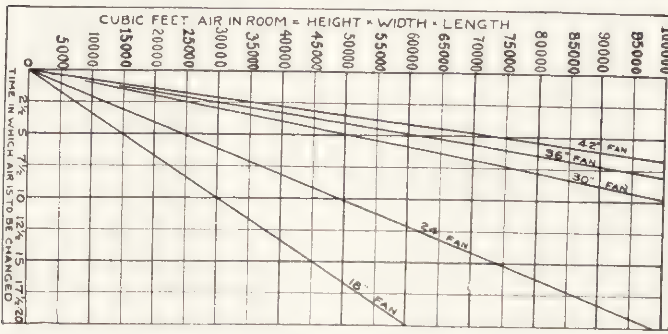


Table 12, Figure 299.

tilation. Diagram, Table 12, Fig. 299, is taken from one of the advertising circulars of the Watson Ventilating Fan.

In order to use this diagram to find the size fan necessary for the foregoing problem, we will draw a horizontal line from six minutes, which would be a little more than half way between five and seven and a half. This line will be drawn out until it crosses a line opposite 36,000 in the cubic contents column, and we find that in order to secure a change of air in six minutes we must use a 24-inch fan, although it will lack a little of the requirement. To make the matter a little more clear, first find the number of minutes in which the air in the room must be changed. Next draw a horizontal line from the time until it crosses a line vertically from the cubic contents of the room, and the diagonal fan-size line nearest will indicate the necessary size of the fan.

As to Heating, it is too large a subject to be dealt with in detail in this book. The usual temperature it is desired to maintain is 70 degrees Fahrenheit. There are three available methods of heating—hot air, which is comparatively cheap of installation but difficult to manage with any degree of satisfaction when it comes to heating a large auditorium; steam heat, which is more costly, both in installation and operation, than hot air; and hot water, which is the most costly of all to install, but the cheapest in operation. The relative cost of installation as between hot air, steam and hot water is 9, 13, and 15; that is to say, that is the ratio. The ratio of cost of operation is: Hot air, 29¾; steam, 29, and hot water, 27.

Steam seems to be the system best calculated to meet the requirements of the theatre. Its principal advantage is its ability to heat uniformly, regardless of the action of wind and its comparative immunity from danger of freezing. Steam heating may be by gravity or non-gravity return, or may be low pressure or high pressure.

Steam and hot water heat is supplied by means either of pipes or radiators, or both, and the heat may be supplied by locating the heating apparatus inside an air chamber and blowing the air through the coils, or by locating the radiators inside the auditorium, in which case there should be a goodly amount of heating surface in the foyer, if there is one, and in the entryway, in order to temper the air drawn in through the entrance and exit openings.

In order to find the square feet of direct radiation required for a given space, divide the cubic contents of the room by the following factors: Auditorium in which there are windows or other exposure, 60; where there are no such openings, 100. Dressing rooms, one side exposed, divide by 40 to

50, according to the window space; dressing rooms, with two sides exposed, divide by 30 to 40, according to the window space.

As to the best apparatus, it would be an almost endless task to go into that. For the comparatively small theatre I think that when we consider cost of installation and efficiency the small cast iron boiler will best serve the purpose, but for a large auditorium the fire box boiler is, all things considered, probably best. The horizontal tubular boiler is a little more efficient, but it requires brick settings and more space.

In winter time it is possible to secure very good ventilation of a theatre by means of a double smoke flue for the boiler of the heating apparatus. To accomplish this the inner flue must be of metal and must be surrounded by a second flue of larger diameter, the air space between the two being connected, by a proper duct, to a point near the ceiling of the auditorium. The heat of the smoke flue will cause considerable suction in the air space, and this, of course, will draw out the foul air from the auditorium.

Lighting the Auditorium

IT is utterly impossible to deal with this subject except in generalties, because conditions in different houses vary so widely; also the ideas of theatre managers are at such variance on the subject of auditorium lighting that it is, I think, not advisable to attempt giving anything more than such general rules as will apply in all cases.

In the first place, it is absolutely essential to high class projection, or even to good projection, that no direct rays of light, other than those from the lens of the moving picture machine, be allowed to reach the screen. The first important step in auditorium lighting is to make sure that there is no light in the auditorium, except the picture light coming from the projector lens and the rays from the lighting system of the auditorium.

To test this matter, close all the doors and whatever is used to darken the windows, switch off all the auditorium lights, and see if any light enters from without—this, of course, applying to day time. If any daylight enters, take such steps as may be necessary to exclude it, and

Under no circumstances allow rays of sunlight to reach the screen.

Having finished this test, next open the entrance doors and the doors through which individuals in the audience

pass out during the performance, and examine the screen carefully. If, with these doors open, shadows appear on the screen, then you must take such steps as will prevent that condition.

At night the projection may be injured by stray light emanating from (a) operating room; (b) the piano or orchestra lamps; (c) incandescent lights in the auditorium; (d) indirect lighting fixtures wrongly placed, or containing too many lighted globes, or globes of too high candle power.

Conditions vary so greatly in different houses that no concrete advice can be given, except to advise the manager to carefully examine into these matters, and if stray light is reaching the screen in such way as to cause its uneven illumination (the test should be made with the projector light shut off) then such steps should be taken as will prevent that condition.

Light for the Musicians.—One of the most common blunders made in moving picture theatre lighting is found in the lights supplied to musicians. As a general proposition they are altogether too brilliant, and, also, in many cases are very poorly shaded. It is no uncommon thing to find a moving picture theatre with the piano close to the screen and its entire upper half covered with white light from a 16 c. p. incandescent lamp. This is worse than foolish. It is literally an outrage, because it adds an absolutely unnecessary element of eyestrain which is felt by practically every one of the audience. They look at the picture, but their eyes are either consciously or unconsciously affected by that big splotch of white light on the piano.

The piano light should never be more than 6 c. p. and I believe 2 c. p. is ample; also it should be so shaded that only the sheet of music being played is illuminated. This may not be quite so nice for the musician, but it is a whole lot better for the audience.

Where there is an orchestra the same thing applies. Use low c. p. globes and *pay very careful attention to their shading,* to the end that only the sheet of music being played receives illumination. Light amber colored globes are to be preferred to white. There is less glare and it is easier on the musician's eyes.

Lights Around the Screen.—A few years ago it was a common practice—and I am sorry to say that practice is still followed in a few theatres—to place a row of incandescent lamps clear around the two sides and top of the screen, to be burned during intermissions. This practice is worse than

bad. It decidedly is no joke to be compelled to stare at anywhere from twenty to forty incandescent lamps for any considerable period of time. Try it once and see for yourself. If your eyes don't hurt after the first few minutes then you certainly have a wonderful pair of optics. If you have anything of that sort in your theatre, Mr. Manager, for heaven's sake yank it out, and stand not upon the order of doing it. It is a crime against your audience.

How Much Light.—The amount of light to be used in the auditorium is a matter concerning which there has been a great deal of pretty hot debate. The self-appointed guardians of the morals of moving picture theatres (who usually carefully overlook the glaring defects in the morals of the burlesque houses and legitimate stage) generally demand an utterly unreasonable amount of illumination in the auditorium of the moving picture theatre, notwithstanding the fact that this excessive illumination serves absolutely no good purpose and operates to very largely detract from the excellence of the show. It is freely conceded that a dark theatre is not an ideal condition, particularly in our larger cities, but

The writer emphatically insists that any illumination other than an amount sufficient to enable one standing in the darkest portion of the house to distinguish the features of those around him for a distance of say six or at the most eight feet is unnecessary, and therefore undesirable.

The only argument that legitimately can be advanced for the illumination of the auditorium of the moving picture theatre is the possibility of improper conduct on the part of patrons seated in a dark auditorium, but I believe any sane and unprejudiced person will admit that if there is sufficient light to enable one to distinguish features six to eight feet away, there is sufficient light to reduce the possibility of anything of that sort to a negligible quantity.

As to the kind of lighting, the writer believes that a properly installed indirect lighting system is, everything considered, best. What is known as the indirect lighting system consists of incandescent globes in fixtures, typical examples of which are shown in Fig. 300, the same being entirely inclosed at the bottom and entirely open at the top, so that all the rays of light from the lamps within are directed upward toward the ceiling, whence they are reflected downward in diffused form.

There is an almost endless variety of design of these fixtures, ranging from $10 each to as high as you wish to go,

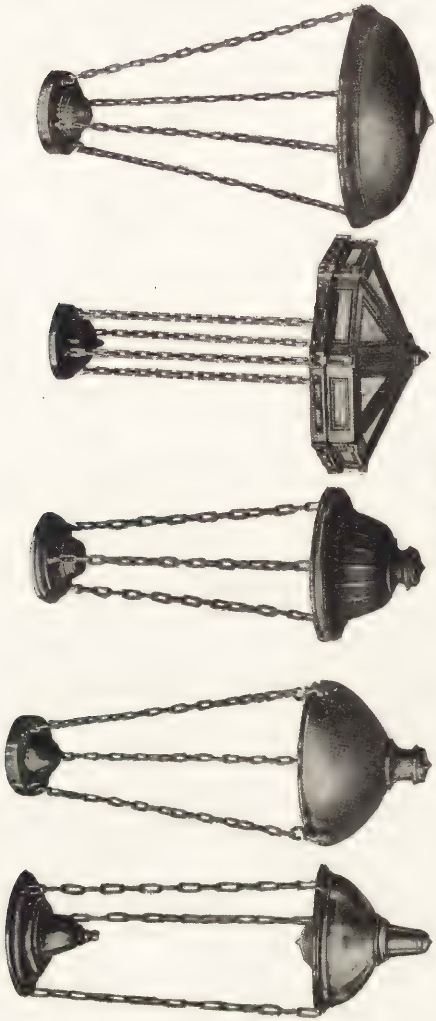


Figure 300.

some being made of metal, some of other opaque substances, and some opalescent or semi-transparent. The last named are very pretty, but I very much question the advisability of using them. I believe the opaque fixture is much better for moving picture theatre lighting. Properly selected indirect lighting fixtures add to the appearance of the room. Where this system is used the ceiling should be of some comparatively light color, a cream or very light tan or green being, I believe everything considered, best.

Caution: When installing indirect lighting systems great care should be had that there are not too many fixtures and that the fixtures do not contain too many lamps designed to burn during the performance, or that the lamps designed to burn during the performance be not of too high c. p. It is easy to overdo indirect lighting, and thus injure the projection. It is well to have the installing company guarantee that the installation will be so made that with the projection shut off and burning the indirect lights which will be used while the picture is on, the illumination of the screen will be uniform all over, without any trace of shadow.

When installing indirect lighting the lamps should, of course, be on two or more circuits, one of which must carry the number of lamps it is designed to use while the picture is on, and the other circuit, or circuits, to carry additional lamps to be lighted during intermissions, thus bringing the auditorium illumination up to its full value when the picture is off. BE CAREFUL AND DO NOT LOCATE FIXTURES TOO NEAR THE SCREEN.

Lighting moving picture theatre auditoriums is not a matter to be undertaken haphazard. It is a problem for an illumination engineer who is thoroughly versed in matters pertaining to the projection of pictures.

Shado-Lite.—As long ago as five years the author of this work recommended the scheme of lighting illustrated in Fig. 301. He still recommends that plan, and believes it to be ideal, *if rightly carried out.* However, there has been a lighting scheme evolved, known as "Shado-Lite," illustrated in Fig. 302. This plan seems to me with a little modification to be excellent. The light is thrown on the back of the audience, and is kept entirely away from the screen, the reflection being for the main part downward and backward. The only criticism I have to make on this scheme is that the light should, I think, not strike the front theater wall at all, but just reach the top of the front row of seats. This plan of lighting is put forward by the Shado-Lite Manufacturing

Company, Beaver Falls, Pa. I would recommend it to the serious consideration of theatre managers.

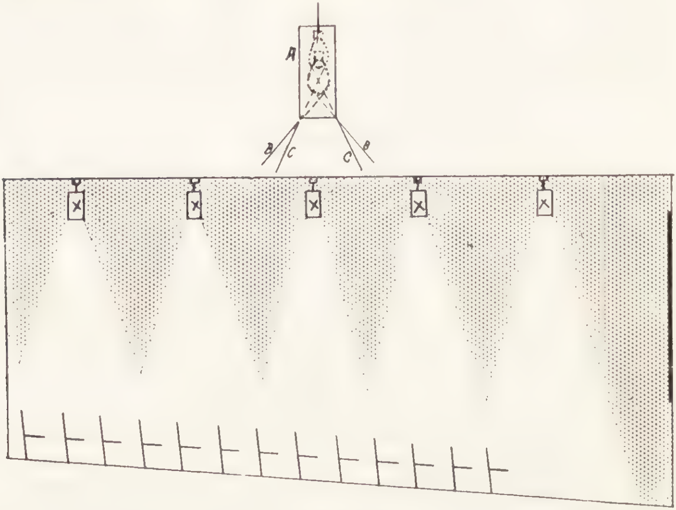


Figure 301.

In considering house lighting it is well to remember that the decoration of the auditorium has very decided effect on the amount of light it will be necessary to use. Illumination is largely a question of the amount of light reflected, hence when using an indirect lighting system a ceiling of light color will reflect a far greater percentage of light than will one of dark color. The same is true of the walls of the theatre. The percentage of light reflected by different surfaces is given different values by different authorities. I think the following is approximately correct:

	Per Cent.
Black, without gloss	1
Chocolate, without gloss	5
Dark Red, without gloss	13
Dark Brown, without gloss	14
Blue, without gloss	26
Yellow, without gloss	45
White, without gloss	75
White, glossy	85

It must be remembered that whereas light colors are more cheerful and as a rule more pleasing to the eye, still they will, to a much greater extent than will dark colors, reflect any stray light there may be, and thus cause maximum injury to the projection. Dark colors, on the other hand, while they give the theatre a more sombre appearance, serve an excellent purpose in absorbing or very largely absorbing stray light. The best plan is to *steer a middle course and select colors neither very dark nor very light.* Where an indirect lighting system is used in my opinion a very light tan or cream color is best for the ceiling. It gives a mellow tone to the light, which is pleasing to the eye. For the side walls

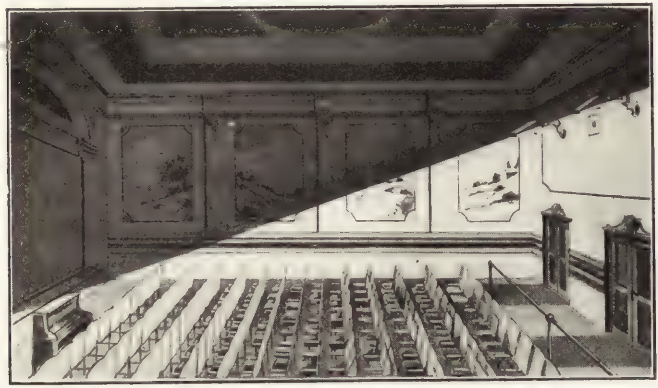


Figure 302.

there is a wide range of selection, but I would avoid bright blues, bright red, and bright yellows. In fact *subdued tints are always to be preferred* to extremes either in light or dark colors.

To go into the matter of colors fully and in detail would require a vast amount of space. In fact, theatre decoration is a topic which in itself would form a very interesting book of goodly size.

Side lights on the walls are distinctly objectionable. They serve no purpose which cannot better be served by the main ceiling lighting system. It is possible to add greatly to the *decoration* of the room by carefully selected ornamental opalescent glass fixtures containing a low c. p. incandescent, placed at appropriate intervals around the sides of the room from

six to eight feet from the floor. One of the most pleasing effects we have yet seen used in this connection is a glass "torch," something like two feet long, the "flame" lighted by a small incandescent. This gives off no illumination at all, merely serving as an ornament. The design of these ornaments are legion, and it is up to the manager to select those best suited to his needs, remembering always that the colors should be reasonably dark. *Don't try to get any illumination from the fixture. Treat it purely as an ornament, showing beautiful designs, in colors, but not too brightly.*

Shaded Exit Lights.—There is a vast amount of crass stupidity or carelessness displayed in many theatres with reference to the exit lights. Don't just have a sheet of ground glass with red or black letters on it. *So construct the box for the exit lights that no light at all can escape from it.* That is very easy if it is to be electrically lighted, but if lighted by gas the use of a properly hooded ventilator is involved. *Paint the space where the letters will come bright red and then have the letters blocked out in black and all the rest of the glass painted black, so that only the letters will show.* In case you use a stock ground glass with red letters on it, my advice is to paint everything but the red letters solid black, the point being that you don't want any of the white light showing—just the red letters.

All too often you find the two front exit lights smearing light all over the front wall, their rays often shining directly on the screen. Such work is very coarse. It displays rank stupidity or absolute carelessness on the part of the one responsible, and either one of those two things spell incompetency.

All auditorium lights, except those designed to be kept burning during the performance, should be handled by dimmers, full description of which, together with prices, etc., may be had from any dealer in general theatrical supplies. A gradual lowering and turning on of the lights has a far more pleasing effect than their switching off and on. Dimmers are not very expensive and are a mighty good investment.

SLOPE OF AUDITORIUM FLOOR

The question is often asked, by those contemplating the construction of a moving picture theatre, "What slope ought I to give the auditorium floor?" This question is quite difficult to answer, since it involves several points, each of which must receive very careful consideration.

In the first place, the main auditorium floor and the bal-

cony floor present two entirely separate and different propositions. The center of the screen is considerable above the main auditorium floor. Therefore, since the audience must look upward toward the center of the screen, it is not necessary that the main auditorium floor be given so sharp a slope as is necessary in the balcony, where the audience must look downward toward the center of the screen.

The slope to be given will necessarily depend somewhat upon the length of the house. It will ordinarily be impracticable to give the main auditorium floor of the long house as steep a pitch as is practical with the short house. Where the front of the balcony is situated a long distance from the screen, it is not necessary to have so steep a pitch in the balcony as where it is up comparatively close to the picture.

As a general proposition I believe that for the main auditorium floor one foot in ten will be found to be very satisfactory. Where it is practical to do so one may increase this considerably with advantage, up to the point where the slope of the aisle becomes too abrupt for safety. Less than one foot in ten will not be found entirely satisfactory. The slope of the balcony floor should be so figured that, using the center of the screen for a point, a line drawn to the back of a row of chairs will come as far above the top of the row of chairs ahead as a line drawn from the center of the screen to a row of chairs in the auditorium will come from the top of the next row ahead, taking a row of chairs in the auditorium immediately under the balcony for an example. This can all very easily be laid out on paper, and it may be found that it will be impracticable to have this amount of slope to the balcony, but it should be done if possible, except in cases where the screen sets abnormally high, or the slope of the main floor is unusually heavy.

I think you see the idea I am trying to convey, and will understand that it will of necessity have to be modified to fit circumstances. One foot in ten of slope will provide a rise of almost three inches between chair rows spaced 28 inches.

Above all things avoid steps, either in the aisles or entering the theatre. Steps in an aisle are absolutely not to be considered under any circumstances. In panic they would be highly dangerous. Steps at the entrance cannot always be avoided, but they are, nevertheless, very bad, and wherever possible a slope should be substituted. Steps for the seat rows very considerably increase the cost of cleaning; otherwise they are not objectionable.

Seating

SEATING is, to the average manager, one of the important problems. The first consideration in a moving picture theatre is excellence in projection, and the second is making the audience comfortable. The requirements of moving picture theatre seating has, to a considerable extent, changed during the past two years. Just a comparatively short time ago but very few moving picture patrons expected to remain longer than one hour. In fact one hour was considered the average time for a "picture show." Now, however, some of the larger, more pretentious city theatres, and in some instances the better theatres in smaller cities are putting on elaborate feature plays, such as "The Birth of a Nation," "Cabiria" and other similar productions, which require two hours or more for their proper presentation. When the patron only remains a short time, a comparatively narrow, cheap seat will be quite satisfactory, but when one is to remain in a chair for two or two and a half hours, with only one short intermission, or no intermission at all, a very different problem is presented. The chair must then be fairly commodious, and at least fairly comfortable. Seats may be 18, 19, 20 or 22 inches wide. In small towns where the show is comparatively short, the seating space usually quite limited, and the admission price low, it is quite possible to use the 19 or even the 18 inch seat with fairly good results, nor is it necessary to purchase expensive seats. There are some very excellent theatre seats with wooden backs and seats, which may be had at surprisingly low figures considering the quality of material and workmanship. These chairs ought to serve very well in a five-cent house, or even in a small town ten-cent theatre. In the larger cities, however, where competition is keen, the shows longer, and the price of admission higher, the theatre manager will do well to use a 20-inch seat, of at least fairly good quality. Imitation leather upholstery may be had, which is durable, handsome, and very reasonable in price. I doubt the advisability of using anything wider than 20 inches in a moving picture theatre, unless it be a theatre de luxe which caters to a high class trade at good prices and which presents a very long show.

I would in any event strongly advise theatre managers religiously to avoid any kind of cloth upholstery. It is difficult to keep clean, is a dust gatherer, and adds materially to the expense of janitor work; also it is hot and "stuffy."

Imitation leather is far superior; even plain wood is distinctly better.

I do not propose, however, to dwell on this subject, since regardless of what I or anyone else may say, it has been my observation and experience that each manager is guided largely by his own ideas and the blandishments of seat salesmen in his selection of seats.

The front row of seats ought never to be placed less than 20 feet from the screen. If the picture be a large one, even that distance may well be increased. (See "Eye Strain," Pages 153, 175, 472.) Assuming the picture to be 12 feet or more, the best view of it is not had until one is at least 50 feet from the screen, and *the ideal view is had at any distance between 50 and 100 feet.* This item should be taken into consideration by managers, and

If there is a difference in the price of parquet seats, those near the screen should be the cheaper. That is the practice in England, and it is the correct practice. The best seats are at the rear.

Loge Seats.—One scheme successfully carried out in some of our western cities is the placing at the front of the balcony and (or) at the rear of the auditorium of a row of boxes containing comfortable chairs, preferably of wicker work of neat, strong design. These loges or boxes will, if properly arranged, occupy the ideal picture viewing location, and the seats therein should sell at a considerable advance over parquet seats. For instance: If parquet seats sell at 25 cents loge seats should bring 35 or 40 cents. You will find that when Willy Boy takes his inamorata to the show he will swell out his manly chest and buy two loge seats. It costs him 20 or 30 cents extra and is worth at least five times the amount to him in gratified pride, but aside from the opportunity presented the young gentleman to swell up, he really gets his money's worth in a more comfortable seat, plus an ideal view of the picture. In a large house, having a circular balcony and a circular auditorium back, it is possible to have a great many of these boxes, and they have almost without exception proved to be a splendid investment wherever installed.

Figuring Seating Capacity.—Figuring the seating capacity of a room of given size is a deep, dense mystery to many, but it is, as a matter of fact, an extremely simple problem.

Distance Between Rows.—Usually local law specifies the minimum distance from chair to chair back—that is to say, the distance the rows of chairs may be spaced. Thirty-two

inches is a distance which meets the requirements of comfort, and all reasonable requirements of safety as well.

It is very poor policy to place the chair rows too close together in an endeavor to increase seating capacity. You will lose money by so doing. It makes your patrons uncomfortable and renders it difficult to pass in and out, since the knees of seated patrons are jammed right up against the row of seats ahead. Moreover in case of panic, the rows being too close together create an additional element of danger.

Thirty-two inches from chair back to chair back is the distance the writer advises, and he strongly advises against anything less than this. To secure additional comfort and elegance in high priced theatres some even advocate a distance of thirty-six inches, but this reduces the number of seats very considerably. Remember that as chair backs always slope backward, the higher the chair the less room there will be for patrons to pass in or out.

The Aisle.—The width of aisles is also usually covered by local law. It is difficult to give any hard and fast rules to this particular item, since the size and shape of the auditorium cuts a very decided figure in the matter. Where the banks of seats are short from front to rear—that is to say, in a short auditorium—it is not necessary to have as wide an aisle as where the house is very long. Particularly is this true if the banks of seats be not very wide between aisles. Aisle width is largely a question of the comfort of the audience in passing out after the show is over and the providing of ample space in case of fire or other panic. For the ordinary theatre auditorium, 3½ feet at the front is the proper width for center aisles, gradually increasing in width to 4 feet at the rear. If the aisle exceeds 40 feet in length, or serves more than ten seats on either side, then its width should be extended to 4½ feet at the rear. Side aisles need not have as great a width as the center aisle, by reason of the fact that they serve seats only on one side, whereas the center aisle serves seats on both sides.

Let us assume, for instance, that we have a room 80 feet long by 40 feet in width. The necessity for a rear aisle will be governed by local conditions. There may be no necessity for any at all. But assuming, for instance, that there are two entrances, as shown in Fig. 303, then there ought to be a 6-foot aisle at the rear. The front seats should be 20 feet from the screen, therefore we subtract $20 + 6 = 26$ feet from seating space, leaving a total of 54 feet for seats. Now since the aisle is more than 40 feet long, we fix the width of the center

aisle at 4 feet, and since the side aisle only serves half as many seats as the center aisle we fix their width at 3 feet which, subtracting $4 + 3 + 3 = 10$ feet from the total width, leaves a total of 30 feet. We will, therefore, have two sections of seats, each 15 feet wide. Chairs may be had in

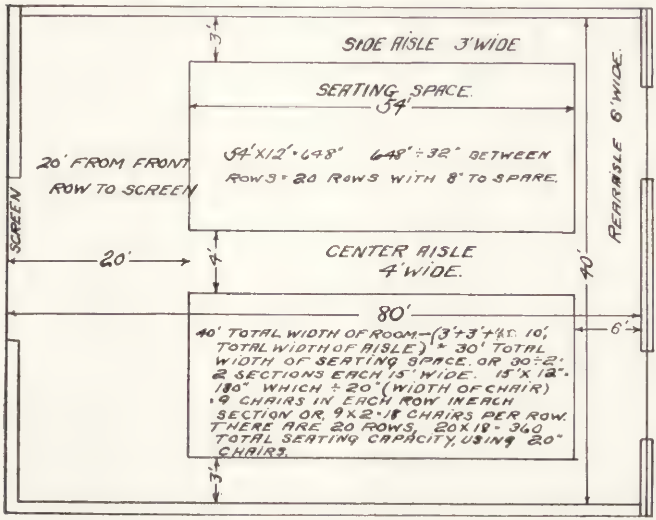


Figure 303.

varying widths. Suppose we select one 20 inches wide; 15 feet equals 180 inches; each row in each section of seats will therefore accommodate as many chairs as the width of one chair is contained into the total width of the section, or, in this case, as many chairs as 20 is contained into 180, which is nine times. We will therefore have nine seats in each row in each section, or $9 \times 2 = 18$ in each row in both sections combined. If we used 18-inch chairs we would have $180 \div 18 = 10$ chairs in each row section, or $10 \times 2 = 20$ chairs in each row of seats—a gain of two chairs per row as against the 20 inch chair. If the sections were, after deducting aisle space, only 176 inches instead of 180, then we would lose one chair in each row of each section, and have very wide aisles, unless local law would permit of contracting the side aisles four inches. Center aisles must never be of less width than the figures given.

The seating space is 54 feet long or deep, and 54 feet equals 648 inches. Fixing 32 inches as the distance between chair row, chair back to chair back, we will have as many rows as $648 \div 32 = 20$, and 8 inches over. We will therefore have twenty rows of seats with 8 inches to spare, and since there are 18 seats in each row we will have a total seating capacity of $18 \times 20 = 360$ seats.

It seems to me this ought to be perfectly plain, and very easily understood. Local conditions will vary the results. For instance: if we could use the additional 6 feet at the rear, we would have $6 \times 12 = 72$ inches additional seating space, which added to the original 648 inches would give us 720 inches. and $720 \div 32 = 22$ rows of seats with 16 inches over. We could therefore have 22 rows of seats, and by decreasing the distance from the screen by 1½ feet could have 23 rows.

It would be utterly impossible to take up and consider all the various hundreds of conditions which may arise, but the principle is always the same, and is easy of application. Here is the rule:

Subtract from the total length of the house the distance from the screen to the front row of chairs, and the width of any aisle there may be at the rear of the last row of seats. This gives you the total length of your seating space, which, reduced to inches and divided by the inches from chair back to chair back (I recommend 32 inches), gives the total number of rows of seats.

Lay out the width of the house on paper, to scale, leaving space equal to the width of the aisles, and thus determine the exact width of each section of seats. Reduce the width of each section to inches, and divide by the width of the chairs you have selected, in inches. This will give you the number of chairs in each row of each section of seats, which multiplied by the number of rows in the section will give you the total number of chairs it contains. Proceed thus with each section, and then add the total together and you will have your total seating capacity.

Where the auditorium is built especially for a theatre and has curved rows of seats, it is presumed that the architect will plot out the floor, and tell you the seating capacity. However, if you are your own architect you will simply be obliged to lay the whole thing out to scale and plot it, since if the sections or banks of seats be fan-shaped, there will be a greater number of seats in each section at the rear than at the front. Here again you simply have to figure the length

in inches of each space and divide by width of chairs selected to determine number of seats. In fan-shaped banks of seats it might even be permissible slightly to contract the width of aisle toward the screen in order to place a given number of seats in the shorter spaces, but on no account should the aisles be narrowed toward the rear or exits, even if local regulations permit.

CARPETING

Theatre aisles should be carpeted with some deadening material, such as heavy linoleum, cork matting or fibre matting. The latter, however, is not to be recommended for the same reason which bars the use of carpet; it collects too much dirt, and on rainy days becomes literally a dirt reservoir.

Some managers who have cement floors prefer not to use any covering at all, but this, I think, is not good practice. It looks too bare and cold. I believe that linoleum, carefully selected as to pattern, or cork matting are always well worth the cost as a covering for theatre aisles. This, of course, does not apply to the gallery, if there is one, but it does apply to the balcony. Where a theatre has a main floor, balcony and gallery, the latter is usually largely turned over to the use of more or less rough boys, who care little or nothing for the finer refinements of life, and a bare floor will probably suit them just as well as anything else, but down below these things not only add to the appearance, but they prevent annoyance to the audience by the noise of people coming in and going out.

Cork matting of good grade is expensive, but it forms an ideal floor covering, in that it is not only an excellent noise deadener, but also is not slippery when wet; also it is handsome in appearance and is clean and sanitary. It may be attached firmly to the floor and remain there until it is worn out, an important point in its favor. There are two minor objections to linoleum, the first being that it is a little more slippery than cork matting, which is objectionable on wet days, if the aisles are steep; also in damp weather it has a certain tendency to expand and wrinkle up. Cocoa matting, firmly secured to the floor, is the best thing to prevent slipping on steep aisles, but it is also the finest dirt reservoir imaginable. Where it is used it should be taken up, carried out doors and beaten, and the floor under it cleaned every day.

BELL WIRING

I do not think I could improve matters by changing the text matter on this subject as contained in the second edition, therefore it is reproduced just as it was.

The electric bell and annunciator play quite an important part in the scheme of things in a theatre. The installation of a single bell is a very simple matter—so simple, indeed, that a child might successfully install one. It is illustrated in Fig. 304. After installing the bell and the push-button in the location desired, one wire is run directly from one side of the push-button to the bell. Another wire is run from the other side of the bell to one side (either one, it makes no difference) of the battery, and another wire is run from the other side of the battery to the other side of the push-button. This completes the installation. For a single bell one battery alone or two batteries in series may be used. By series I mean two batteries, with the carbon of one battery connected to the zinc of the other battery by means of a short wire, as at A, Fig. 306. The effect of two batteries connected thus is to cause the bell to ring louder. Two batteries in series will not last twice as long as will one working alone.

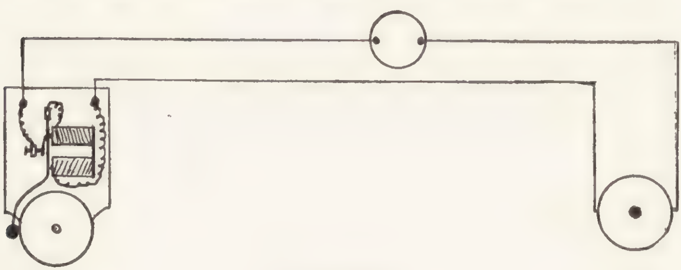


Figure 304.

The ordinary practice in moving picture theatres is to use either bells, buzzers, or small, low candle power lamps for signaling to the operating room, piano player and the manager. Of the three, the lamp system, if properly installed, is the best, with the buzzer as second. The bell should never be used. A buzzer is merely an electric bell without the bell part.

What is known commercially as the dry battery is best for theatre work. Wet batteries are very effective, and very cheap in operation, but they are liable to freeze up in winter

and thus cause a lot of trouble. The dry battery is cheap and effective.

It is possible to renew dry batteries when they have "rundown" by taking off the cardboard casing and punching several holes in the lead casing about an inch from the top; being careful, however, not to break the carbon of the battery in the process. An ordinary nail may be used to punch the holes. Be careful also not to disturb the sealing wax around the top. Having done this, immerse the batteries in a solution of one pound of sal ammoniac to one gallon of water, and leave them for an hour or so, after which remove and stand them upside down for one hour, to allow the surplus solution to thoroughly drain out. In draining the batteries be careful that the solution does not form a contact between two binding posts, since it will carry current, and will thus short-circuit the battery and run it down rapidly. When thoroughly drained, wipe the battery dry, replace the cardboard casing and it is ready for use.

For wiring bells No. 18 ordinary cotton covered bell wire is plenty good enough, unless the circuit be a very long one, in which case No. 16 might be used. This holds good, except in very wet places, where it is better to use rubber covered wires, supported upon porcelain insulators.

In putting up bell wires they may be gathered together in a cable and held to the wall with a wooden cleat. They may be run singly around picture molding, being held thereto by

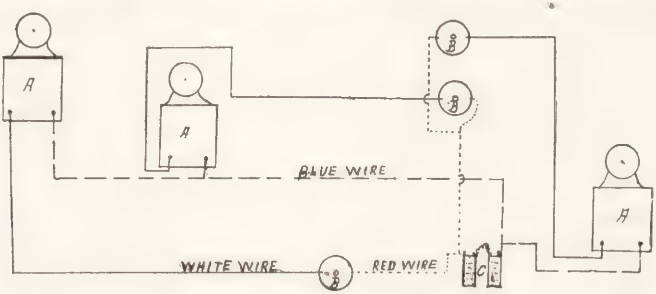


Figure 305.

small iron staples, but where this is done a staple should never be driven over two wires, since it is likely to cut through the insulation and short-circuit the bell, the battery or both. Never drive a staple over two wires. Hold each wire with its own staples. A short circuit may cause your

bell to ring all the time or not ring at all, according to its location. If on the two wires leading to the push-button the bell will ring continuously until the battery is worn out. If on the wire running from bell to battery and the wire running from button to bell the bell will not ring at all. Joints in the wire should be made in the usual way (see wire splices, Page 89), and should be soldered and wrapped with insulating tape. Never run your wires in a slipshod manner. Always do a job in a workmanlike way. Stretch the wires tightly and run them as they should be run. Loose, sagging wires advertise the poor workman.

A, Fig. 306, shows series connection of batteries, which has the effect of raising the pressure approximately one volt for each battery added. B shows multiple connection, which increases amperage but not the voltage, and C a series-multiple connection which increases both volts and amperes.

A very common practice in theatres is to use what is known as the three wire system of bell wiring. This system is the most economical in that it requires a comparatively small amount of wire for the installation of several bells. By its use any number of bells may be rung with one battery, and each bell has its own individual push-button. No push-button will ring any bell but its own. Put up the bells, buzzers, or lights and the push-button wherever you wish them to be. Use two batteries, connecting the carbon of one to the zinc of the other. Get bell wire of three different colors. The installation is illustrated in Fig. 305, in which A-A-A are bells, B-B-B push-buttons, and C a two-cell dry battery.

The reason for three colors is to avoid mistakes and confusion and to be able to find any particular wire anywhere afterward, without tracing it clear from the battery or bell. The use of three colors of wire simplifies matters very greatly. Suppose you get red, blue and white. You take one color, say the blue, and run it from one (either) binding post of the battery to one (either) binding post of each bell. You may run separate wires from the battery binding post to each bell or run one wire reaching all bells or you may branch off to a bell at any point. Next take another color (red, for instance), and run from the other battery binding post to one (either) side of each push button. You now have one side of the battery connected to one side of each bell and the other side of the battery connected to one side of each push-button. You next, with the remaining color (white) wire, connect the remaining side of each push-button with the remaining side of the bell it is to ring, and the job is done. The blue wire (blue in this case) is called the common bell wire, the red wire

is called the push button wire and the whites are called the individual wires. It is these latter wires which determine which bell a button will ring and you may cause a button to ring a different bell by simply changing the individual wire to that bell. Fig. 305 shows a plan of this system.

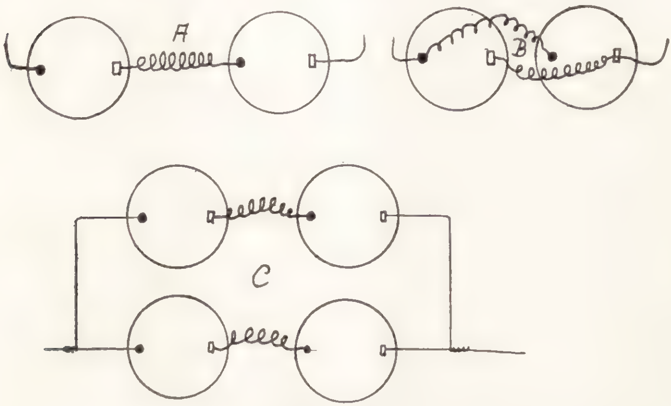


Figure 306.

An additional bell easily may be installed at any time as follows: Test the bell and install it and its push-button wherever you want them to be. Now with a piece of first color wire connect one binding post of the bell with the first color wire already in use wherever you can find it. With a piece of second color wire connect one side of the push-button with a second color wire wherever you can find one. Understand you can just tap on to these wires at any point you can locate one of proper color. Now connect the remaining side of the button with the remaining side of the bell with third color wire and the job is done. The rules governing this system of wiring are as follows: One side of the battery must be connected with one side of each bell by first color wire. The other side of the battery must be connected to one side of each push-button with second color wire and the remaining side of each button must be connected with the remaining side of the bell it is to ring with third color wire.

The various battery combinations are illustrated in Fig. 306. A increases the voltage without affecting the amperage. B increases amperage without affecting voltage. C increases amperage and voltage. A is series, B multiple and C is a multiple of series.

In Fig. 307 we see two fire bells, one located, let us suppose, in the manager's office, and the other on the stage, or at any other suitable point. We also see an ordinary push-button at A, and a form of contact more suitable to such work at B, either of which will ring both bells. As many of these may be attached as desired, locating them at any point in the house. Attach one

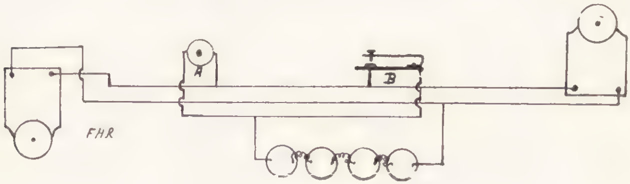


Figure 307.

side of the button to upper wire and the other side to the battery wire, as shown. In the illustration we see four batteries connected in series. This being a fire alarm system, it is desired that the bell or buzzers ring very loudly, hence several batteries are connected in series. Employees should be made to understand that it will mean instant dismissal to ring these bells, except in case of actual necessity. The system can be arranged for any number of bells, from one to a dozen, and there can be as many push-buttons as desired.

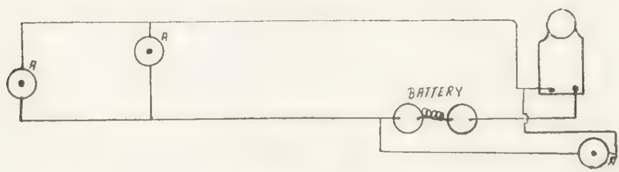


Figure 308.

Fig. 308 illustrates the method of connecting a bell so that it may be rung by more than one button. By this plan as many buttons may be installed as desired, any one of which will ring the bell, provided the wire from push-button to battery wire be not connected between battery and bell. A-A-A are push-buttons.

In Fig. 309 we see the method of wiring an ordinary annunciator. The plan is too plainly shown to require explanation. The buttons may, of course, be located anywhere in the building, and are ordinarily widely separated.

Electric Programme Board. Fig. 310 is the wiring diagram of an electric programme board. I think the action will be plain when you trace through the contacts in Fig. 310.

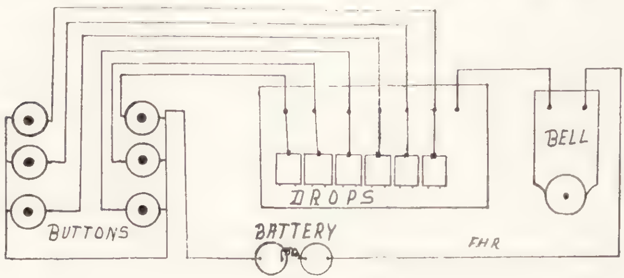


Figure 309.

Wire A, we may call the permanent connection. As you will observe, it connects directly to one side of all the lamps. Wire B connects through switch C and movable arm D to the various contacts 1, 2, 3, 4, etc. Now suppose we place arm D on contact 1. You will observe that the current will flow through wire E. through lamp 1, and thence back through the other wire, and that no other lamp will be affected. If we move the arm to contact 6, then only lamp 6 will be lighted. Such a board is simple,

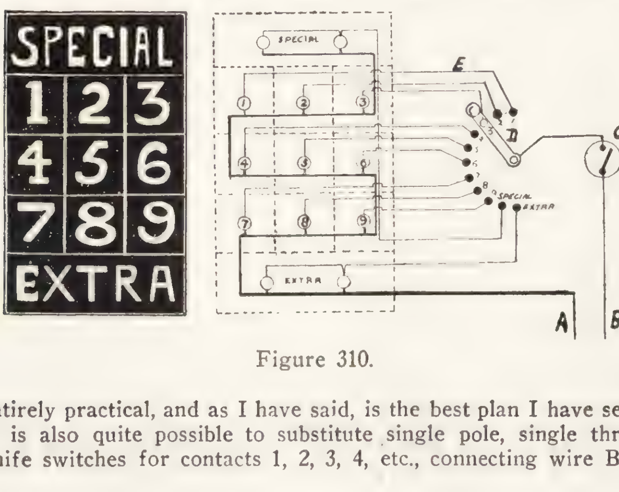


Figure 310.

entirely practical, and as I have said, is the best plan I have seen. It is also quite possible to substitute single pole, single throw knife switches for contacts 1, 2, 3, 4, etc., connecting wire B to

one side of all these switches. The switches or the contacts should be located at the most convenient point, either on the stage, by the side of the musician or in the operating room. The transparency can be so made that only the figure or name actually illuminated will be visible. This may be done by covering the whole front of the board with ground glass, on which are the figures, or names blocked out in black, as shown in the illustration, each lamp, however, being contained in a light tight compartment of its own. Different colors may be obtained, if desired, by covering the various characters with light shades of gelatine or using colored globes.

In practice, I would by all means advise a double-pole single-throw switch at AB, rather than the single-pole knife switch at C. In fact switch C would be a violation of Underwriters' rules.

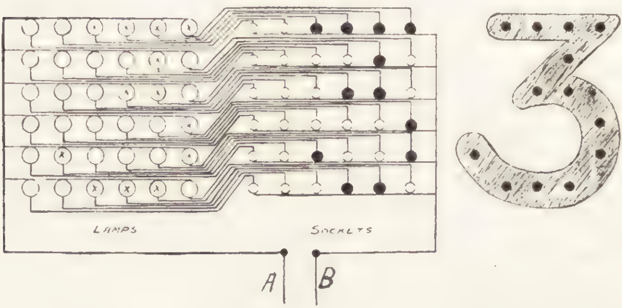


Figure 311.

In Fig. 311 a battery of 36 lamps is arranged in the form of a square, with 6 lamps either way. One wire (wire A, in the sketch) is connected directly to one side of each lamp. A board is now made, containing 36 sockets, arranged in a square, with 6 sockets each way, the same as are the lamps. This board may be placed in any convenient location, either near the lamps or removed at a distance from them, as may be most convenient; but in any event, the other side of each one of the lamp sockets must be connected to one side of each socket as shown. We now connect the other side of each one of these sockets to wire B, as shown in the illustration, installing a double pole, single throw switch, at any convenient point in wires A, B. Both sides of the socket are now alive, one directly from wire B and the other by way of the lamps through wire A. It will be readily seen that if an ordinary plug fuse be screwed into any one socket the lamp connected to that socket by cross wire will immediately

be lighted and will burn until the plug is removed. Suppose we wish to form a figure 3. It would be only necessary to insert the plugs in the sockets indicated, in order to outline the figure 3 on the board, wherever it might be placed. In using such a plug board it is advisable to have a pattern of the various figures and letters it is desired to use. Patterns may be made of cardboard.

Where printed programmes are used it is quite possible to install such a board at the side of the stage, with the plug board and the switch controlling the supply wires located in the operating room, within convenient reach of the operator. He can then plug in any desired number and illuminate the same by merely throwing in the switch, i. e.: Supposing he is running reel 2, the next being, of course, reel 3, which is described on the programme under that number. He prepares Fig. 3 by placing the plugs in position in the board, and as reel 2 is finished he throws in the switch, illuminating Fig. 3, thus allowing the audience to look at the programme while the next reel is being threaded or during the interval between the two reels. Where only one number is to be used the board can be made very small, and it is not necessary to use more than two or three c. p. lamps, these being of the proper voltage of course. Such a board can be used to decided advantage in many ways. The lamps, if used within the auditorium, should be frosted or else heavily colored. It is possible to so connect the various figures through batteries of switches that the plug arrangement is unnecessary. This is more costly, and the plug serves every purpose. It is quite possible to substitute single pole, single throw switches, or ordinary snap switches in place of the plugs. The arrangement shown in Fig. 311 is much the best for programme announcements.

Electric Meters

WHAT is known as the watt-hour meter is the instrument now used for the measuring of electric current. The measurement is in watt-hours, which simply means that a certain number of watts have been used for a certain number of hours, one watt used for one hour being the unit of measurement. The principle of operation of these meters is as follows: The dials which record the consumption are operated by a small motor which is placed in series with the current consuming apparatus. The motor is so constructed that if it were operated at a pressure of one volt for a period of one hour during which time one ampere of current flowed, it would record one watt, or one "watt-

hour." In other words, if the recording motor be run by one ampere at one volt for a period of one hour it would move the dial only just far enough during that hour to record one watt-hour. Using this as a basis we can readily understand that if the pressure be 100 volts and the number of amperes be 2, during the period of one hour the meter would record $100 \times 2 = 200$ watt-hours, or if the voltage be 110 and the number of amperes flowing 20, then during a period of one hour, the meter would record $110 \times 20 = 2200$ watt hours, which would mean, in effect, that 2,200 watts had been used for a period of one hour, since it would, under these conditions, require one hour for the recording hand to reach the 2,200 watt-hour mark. Briefly, the foregoing describes the principle of operation. I hardly think it is either necessary or advisable to consume space in setting forth a diagrammatic representation and elaborate explanation of the methods by which this action is accomplished.

Rough Test of Meter.—The construction of electric meters has reached such a stage of perfection that it is very seldom indeed that they do not record the current consumption with perfect accuracy. However, he who has doubt as to the correctness of his meter may make a rough test by putting in, say, ten *new* incandescent lamps, the wattage consumption of which is at least approximately known, and carefully shutting off all other current consuming devices and disconnecting the operating room leads, allowing these lamps to burn for precisely one hour, first having marked the exact position of the meter dial hands. At the end of the hour shut off the lamps and take another reading.

Caution.—In doing this you should turn the lamps all on and off at once, and not with the socket snap switches, since the time consumed in turning off ten separate lamps by their socket buttons would make an appreciable difference. Suppose you have ten 55-watt lamps, then the meter would show a consumption of 550 watts, or 550 watt-hours during the one hour test, but of course the test is only a rough one, since lamps seldom consume exactly their rated wattage. The reason for disconnecting the operating room leads is to avoid possibility of a ground in the operating room affecting results.

It is well, occasionally, the last thing at night, after everything has been turned off, with a match for illuminant, to take a careful reading of the meter, and then in the morning before anything is turned on take another reading. If there is any difference look for a ground somewhere in your lines. This may be made more effective by leaving the operating

room arc lamp circuit switches in, but with the carbons separated.

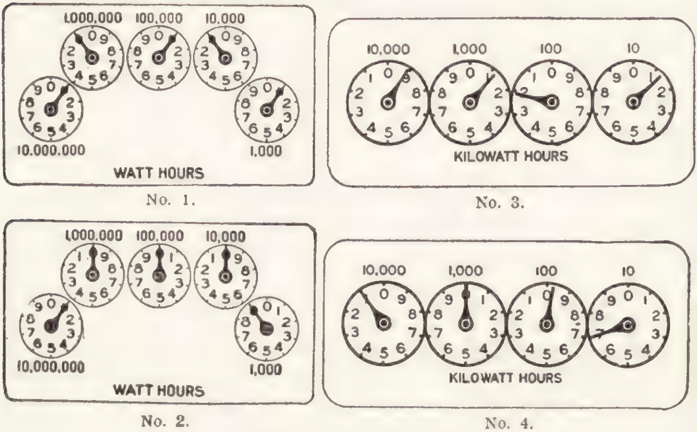
The unit of quantity in which electrical power is measured, and on which your power bills are based, is the watt-hour, or the amperes times volts times hours. One watt-hour is the equivalent of one ampere multiplied by one volt multiplied by one hour. A 55-watt incandescent lamp will consume 55 watt-hours in one hour—that is to say it will consume that amount of power if it is actually using what it is supposed to use, a thing which seldom is true. Therefore if you use twenty-five 55-watt lamps for four hours, your light bill will be $55 \times 25 \times 4 = 5{,}500$ watt-hours, or, 5½ kilowatt-hours ("kilowatt-hours" being a term which means 1,000 watt-hours). If your rate be 8 cents per kilowatt-hour, then the bill for that power would be $5.5 \times 8 = 44$ cents.

There are several different types of meters, but the principle of operation is the same in all. For alternating current the apparatus must, of course, be adapted for use with that kind of power, but I think with those details the operator is not particularly interested.

Reading the Meter.—An electric meter is read precisely as you would read a gas meter. First carefully note the unit in which the dials are read. On all meters used by the Edison Company the figures above or below the dial indicate the value of one complete revolution of the pointer, hence one division indicates one-tenth of the value of the complete revolution. Carefully note the direction of rotation of the dial pointers, as indicated by the figures, the pointers moving of course, to figure 1, to figure 2, and so on around through figure 9 back to 0; also each dial will read in an opposite direction to its neighbor. Counting from the right on the five-dial register the pointers of the first, third and fifth dials of a watt-hour meter rotate in the direction of the hands of a watch, or to the right, while the hands of the second and fourth dials move in the opposite direction. The same is true of the four-dial register—the first and third dials move to the right and the second and fourth to the left. The dials must always be read from right to left and the figures set down as read, carefully remembering that until the hand has reached a division that division does not count. For instance: In No. 3, Fig. 312, the right hand dial has passed 1, but has not reached 2, therefore *it reads* 1, likewise the second, or 100 dial hand has passed 2 but has not reached 3; *therefore it reads* 2.

Taking No. 1, Fig. 312, for example, it reads as follows:

A complete revolution of the right-hand dial would be 1,000 watt-hours, but the pointer has just reached division 1, which being one-tenth of 1,000, is 100. We therefore put down 100.



Facsimiles of Meter Dials.
Figure 312.

The next dial stands at 1, which since one division is one-tenth of the total of 10,000 equals 1,000, therefore we set down 1 at the left of the 100, and have 1,100. The next dial also stands at 1, which being one-tenth of 100,000 is 10,000, so we set down another 1 to the left of the 1,100 and we have 11,100. The next dial stands at 1, so we set down another 1 to the left and have 111,100, and last, the 1,000,000 dial stands at 1, which call for still another 1 at the left and we have a final reading of 1,111,100 watt-hours.

Taking No. 3, which reads in kilowatt-hours, we apply the same principles. The right hand dial registers up to 10 kilowatt-hours. The pointer has passed the 1, but has not reached the 2, so we put down a 1, that being one-tenth of the total of 10. The next dial to the left has passed the 2 but has not reached the 3, therefore we put down a 2 to the left of the 1. The next dial reads 1 and the next 9, so that we have a total reading of 9,121 kilowatt-hours. This seems to be plain enough to be readily understood by almost anyone, but we will consider one more example—No. 2, Fig. 312. Three of the dials stand at 0, the right hand dial stands at 9, and since the total value is 1,000, we would have 900 to

start with, followed by 000 and a 1, or a total of 1,000,900 watt-hours.

Caution.—*Before reading your meter you must ascertain whether it has a direct reading register or one with a multiplying constant.* Some meters are not direct reading, but require that the dial reading be multiplied by a constant in order to obtain the complete reading. This is for the purpose of keeping meters of various capacities of fairly uniform size. If the constant were not used, meters of larger capacity would be of greater dimensions than those of smaller capacity. If the register face bears the words "multiply by 3" you must multiply the actual reading by 3 to obtain the true value. If it reads multiply by any other number, then multiply the actual reading by whatever the given number may be.

The manager or operator should always read the meter when the company's man reads it, and make a record of the reading in a book kept for that purpose. He may then at any time figure his light bill by the simple process of reading the meter, subtracting from this reading the last company reading, and then by multiplying that amount by his rate he can tell precisely what he owes at any given time. Suppose, for instance, when the man reads the meter it registers 297,480 watt-hours, that being the tenth of the month. On the 20th you take another reading and find that it registers 447,580 watt-hours. Subtract one from the other and you find that you have consumed 150,100 watt-hours (we assume a watt-hour register) or 150.1 kilowatt-hours. Supposing your rate to be 7 cents per kilowatt-hour: $150.1 \times 7 = \$10.50$, which will be your current consumption bill for that period.

Maximum Demand Indicators.—Companies base their charge to a considerable extent on the amount of current used, the large consumer getting a lower rate than the small consumer. This is but right and fair, since the proportionate overhead expense is much greater for a small consumer than for a large one. However, in some cases where the load is intermittent, the price to the consumer is based on what is known as the "maximum demand" rate. That is to say if the power consumption at any time exceeds a certain fixed amount for an appreciable period of time, there is an additional charge for the extra power. One form of demand instrument known as the "Wright Demand Indicator" can be used to register or record the highest amount of power used for a period of five minutes or more during any certain period. For instance, where a demand indicator is installed, assuming your normal current consumption to be 50 amperes,

if you used 75 amperes for a period of, say, two or three minutes, the instrument would take no account of the extra consumption, but if you used that 75 amperes for a period of *five minutes or more,* then the indicator would get into action and register 75 amperes, so that when the power company's man came around he would know you had used that amount of current at some time for a period of five minutes or more.

The Wright Demand Indicator is installed near the regular meter, and consists of a U-shaped tube containing sulphuric acid. When connected in circuit the current which is used passes through a coil near one leg of the U-shaped tube, the same being in effect an air chamber the bottom end of which is corked by the mercury. This coil is made of wire calculated to carry a certain definite number of amperes, and so long as the current does not exceed that amount, the coil does not become heated beyond a certain point, but if there is current consumed in excess the coil heats in exact proportion to the excess of current and the heat thus generated expands the air inside the leg of the U tube. This heating and expansion of the air is calculated to consume a period of five minutes, and its effect is to force the liquid up the other leg of the tube and over into an extension chamber, the quantity of liquid forced over being in exact proportion to the degree of heat generated in the coil, and therefore to the amperage used. Having once been forced over, the liquid will remain there, and thus the power company has an indisputable and permanent register of the highest amperage you have used for a period of more than five minutes. At the end of the month a reading is taken of the "demand indicator," and if the column of liquid which has been forced into the measuring tube is beyond a certain amount, the station charges a certain extra amount for extra load. After the reading has been taken, the indicator is unfastened and the tube tilted until the liquid runs back out of the measuring tube into the U tube, whereupon the indicator is again ready to begin operations. The reason for this maximum demand charge is logical and simple when it is once understood.

If a customer ordinarily uses 5,500 watts, or approximately 7 1/3 h. p., the power company supplying him must provide that amount of plant capacity for that particular customer. Allowing for losses in generation, transmission of the current, etc., this means about 10 h. p. in boilers, engines, generators, transmission lines and transformers, in order finally to deliver 7 1/3 h. p. to the customer. It costs real money

to provide plant capacity. The pro rata plant capacity required in this case would represent an investment of $2,000, upon which interest is to be paid and a sum set aside each year to cover the item of depreciation.

The demand system of rates is used so that power companies may get from their customers this interest and depreciation first, and enough to cover the operating expense and profit afterward. I could go on and give you a lot of figures along these lines, but all I seek to do is to explain to you the general action of the indicator, and the reason for its installation. Having covered this point I believe the purpose, so far as the operator or manager be concerned, is fulfilled. I might as a last thought add the following, particularly in view of the fact that the motion picture theatre is often a short time load, which, from the power company's point of view, necessitates the paying of relatively high rates. Suppose one man uses 10 amperes at 110 volts for one hour a day, or $10 \times 110 \times 1 = 1{,}100$ watt-hours; another man uses 1 ampere at 110 volts for 10 hours, or $1 \times 110 \times 10 = 1{,}100$ watt-hours. Now these customers both consume precisely the same number of watt-hours, but *one man uses his plant capacity one hour out of twenty-four, while the other chap uses his for ten hours,* and it naturally follows that the latter is entitled to a lower rate by reason of the fact that the company is not obliged to install added machinery capacity, except for one ampere, whereas in the other case the machinery capacity must provide for the added 10 amperes, although that added machinery will only be in use one hour out of the twenty-four, and must lie idle the rest of the time.

EMPLOYES

A theatre will reap vast advantage by the atmosphere imparted through and by means of neat, energetic, intelligent, uniformed, courteous employes. On the other hand, slovenly, ununiformed, discourteous or careless employes will injure the prestige and seriously decrease the revenue of any theatre.

There are two moving picture theatre employes whose positions are of paramount importance, viz:, the manager and the operator. The manager, of course, has the employment and supervison of all the help, as well as the decision as to programs and many other things of vital importance to the welfare of the theatre. I think few, if any, will argue that it is good business policy to employ an incompetent,

careless man as manager, merely because he may be had cheaply.

The operator has in his hands the making or marring of the performances, and upon his skill and careful, painstaking attention to details depends, in very large degree, the excellence of the picture on the screen. It therefore follows that, since the revenue at the box office is largely dependent upon the result upon the screen, the operator should not only be a man who thoroughly understands the technical details of his profession, but he must also be possessed of sufficient energy to apply that knowledge, and place and maintain on the screen a perfect projection, or projection as nearly perfect as the apparatus at his disposal will produce.

It seems to me that, as in the case of the manager, it is foolish to argue for the employment of a careless, or incompetent operator merely because he is cheap.

The appearance of the theatre lobby very frequently is the deciding factor in inducing the passer-by to enter, or the reverse. The doorman should be a man, and not a more or less irresponsible boy. He should by all means be neatly uniformed and of prepossessing appearance. If the prospective patron sees an ununiformed, unshaved doorman, perhaps slumped down in a chair, or leaning against a convenient wall, he is likely to conclude that the performance is apt to be equally sloppy. I know the term "sloppy" is not elegant, but somehow it fits remarkably well.

The ticket seller should be a bright and attractive young lady, neatly dressed and wideawake. Many a theatre loses patronage it might otherwise get simply because of an untidy looking ticket office presided over by an unprepossessing, gum-chewing girl. Particularly at the front of the house neatness in dress and a wideawake appearance counts for much, and courtesy is above all things highly important.

Within the ushers should be courteous and obliging, continually watching for vacant seats, and seeking at all times for opportunity to do the patron some service. Numberless are the cases where theatres have obtained a steady patron simply through some little act of courtesy on the part of an employe, which in itself amounted to but little, but conveyed to the recipient the idea that the management was looking after his interest and comfort. The wideawake usher will, when the house is well filled, keep in his mind the location of all vacant seats in the section he serves, so that when a party or a single individual enters, he will know just where they can be seated to best advantage. These things

count for much in the mind of the public. It is not an inspiring sight to see patrons parading up and down the aisle looking for seats, while the usher is doing the same thing. Save in exceptional cases the usher ought to know just where those seats are. If he cannot carry such things in his mind, and is not sufficiently energetic to watch closely and make mental note when patrons get up and leave, then he is not the right man for the job.

Moving picture employes should also have carefully impressed upon them the fact that merely because a patron wears a threadbare coat, or a cheap dress, is no reason that he or she is not entitled to receive exactly the same degree of courtesy shown the man or woman dressed in fine raiment.

It is the duty of the manager, and a duty which he will, if he is the right sort of manager, by no means neglect, to spend most of his time around the theatre carefully watching the performance of his employes, checking up results on the screen, and taking careful note of comments of patrons concerning the show, particularly as they leave the theatre. In time the manager will come to know many of his patrons, and their views and ideas will help him greatly in improving the program and the various details of the management of the house. A wise manager can in course of time, by studious courtesy on his own part and enforcing the same on the part of his employes, build up a large personal following for his theatre, which will be very valuable from the dollars and cents point of view. In fact the management of a theatre has so many angles that its careful consideration would require almost if not quite an entire book.

Musicians.—The "musician" may mean a single individual presiding over a piano, or may mean an orchestra of many pieces. It is too large a subject to be dealt with here, except in generalities.

Where a single musician (piano player) is employed it is of the utmost importance that he or she be "on the job" from the time the picture starts until it stops. The presentation of a subject may be immensely improved or may be very greatly injured by the work of the musician. Whether or not a single musician should be uniformed is a question open to argument. I think, however, it will depend considerably on circumstances and the sex of the musician. The piano player must, of course, have a wide repertoire of all kinds of music at instant command, and must be able to play "at sight" almost anything that is written.

It is highly essential that the piano player have a large

fund of good judgment and common sense, since in the smaller theatres it will be seldom possible to rehearse and plan out the music for the show, which latter is, as a rule, changed every day. Therefore it is necessary that the piano player be able instantly to select music which will at least fit in fairly well with the action of the film, and this can only be done by one possessed of not only a large assortment of know-it-by-heart music but also a fund of good judgment.

Where an orchestra is used the members should by all means be uniformed. The subject of orchestras is, however, such a large one that I think it is not advisable to attempt to deal with it.

Connecting Up for Temporary Show

THE following instructions are by no means designed for regular road men. They are presumed to know their business. There are, however, from time to time small exhibitors who travel from town to town with their own outfit, covering only small villages, and this particular chapter is written to point out to them the various things they should look out for in connecting up to the local plant. Also it is quite true that city operators who have had no road experience are frequently employed to go out to some town and give a show in a church, theatre, school or lodge hall, and this is not quite so simple a proposition as appears on the surface.

First, be very sure that your outfit is "all there" before starting out. Unless the exact throw and size of picture is known it is always advisable to take along at least three focal lengths of M. P. and stereopticon lenses, viz: a 3½, 4½ and 6 inch M. P. lens, and a 12, 16 and 21 inch stereo; the latter should always be "half size" lenses. It is necessary that sufficient resistance (rheostats) be taken along to handle the voltage of the current, and, in this connection, there is a book published by the McGraw Publishing Company, 239 West Thirty-ninth Street, New York City, which gives the voltage, kind of current, capacity of the generators, etc., of every town in the United States and Canada. It is published by subscription, and every traveling operator ought to be supplied with one. You should at least take along sufficient resistance to handle 220 volts.

Before starting, examine the whole outfit and be sure you have not omitted some essential part. I have known of

operators going to some distant village to give a show, only to discover upon arrival that, for instance, the machine crank had been left behind, or there were no carbons with the outfit, or that the lamp leads or lenses had been omitted, or there was no empty reel for the lower magazine. In this respect an ounce of prevention is worth more than a ton of cure, and out in an isolated village you will not be able to get a duplicate of any parts you may through your carelessness have omitted.

It is advisable to take with you at least 250 feet of stranded rubber covered wire, size No. 6 B. & S. On arriving at the building where the show is to be given, first ascertain whether the current is A. C. or D. C., and if the former whether or not there is a pole transformer. If there is, investigate and see if it is large enough to supply current to the arc, in addition to whatever else it may be supplying, always remembering that a commercial transformer can carry a 50 per cent overload for an hour or two without in any way injuring it. If you have any doubt whatever as to the transformer being large enough, it will be advisable to see the light plant people about it, and sometimes a good cigar or two will work wonders in convincing the local electrican that the transformer is large enough to carry your load. The next thing is to determine whether or not the wires entering the building have sufficient capacity to supply your arc in addition to whatever else they must supply. It is also necessary to investigate the size of the meter (if there is one) and fuses. If all these various things are found to be of ample size, the next thing is to determine the best place to connect your wires. If there is a panel board near where you desire to locate your machine, and it is fed by wires large enough to carry your arc, plus whatever else they must carry, you may connect to the board, if possible through a circuit service switch. However, this detail will vary with different boards. If there is no panel board, or if the panel board feeders are too small, it will probably be necessary to carry your wires to the main cutout and make connection there. If the wires entering the building are too small you will be compelled to run your own wires out of some convenient window or other opening, and connect to the secondary (if there is a transformer) right up close to the transformer, supporting your wires in any convenient way, high enough so that no one can touch them. In deciding whether or not the wires entering the building are large enough don't forget to figure the load they must carry in addition to your arc. The volt-

age of the current may usually be ascertained by examining the name plate on the meter or pole transformer, or by using your test lamp. If you use a test lamp you should have two 110 volt lamps connected as per Page 257. You first try wires A and B. If the lamp burns to candle power it is approximately 220 volts, and you must have a resistance to handle that pressure. If they only burn to half candle power, then try wires A and C, and if the one lamp thus connected burns to candle power the voltage is 110. Having set up your machine and made all electrical connections, strike an arc and make sure that everything is all right as far as the light is concerned. Try out your mechanism to be sure nothing has become disarranged in shipment. Ordinarily if the show is in a lodge hall, church or schoolhouse you will set your machine on a platform in the auditorium, and you should use a little common sense and judgment in placing your rheostats. Don't locate them where somebody will stumble over them or film fall against them, or under your machine where you will receive all the heat they will generate.

TESTING VOLTAGE

The traveling operator may ascertain the voltage of a system in a number of ways. A voltmeter is best, of course, but such an instrument is seldom available. It is exceedingly unlikely that the voltage in any building will exceed 250. Connect two, ordinary 110 volt incandescent lamps in series, as per wires A-B, Fig. 107, Page 257. Touch the end of the wires A-B, Fig. 107, Page 257, to the circuit wires, to the live binding post of a switch, or to opposite fuse contacts. If the lamps burn above power the voltage is above 220, probably 240, or 250; if they burn at candle power the voltage is approximately 220; if they only glow red, try lamp wires A-C, Fig. 107, Page 257. If it burns to candle power the voltage is 110, if above power it is a little above 110, probably 120 or 125; if below candle power the current is probably 104. If it only glows faint red the current is probably 60 or 70. You may also tell by examining the plate on the meter, if there is one, or on the motors, if there be any, or on the outside transformer if there is any. The practical man can judge voltage very closely by the lamp test, and even the novice cannot make any serious error if he follows the above carefully.

Is the Current A. C. or D. C.?—This point may be determined by (a) looking for a transformer outside the building—if there is one the current is alternating, though its absence does not offer conclusive proof that the current is D. C; (b) by looking at the meter plate, if there is a meter, or by looking at the motor plates, if there are any; (c) by slightly moistening the fingers and touching two wires of opposite polarity, thus taking a slight shock. If it is A. C. the current will feel "jerky." This latter test is not to be recommended to the novice, or anyone else, for that matter, for if you should try it and the wires happen to be crossed with high potential lines it might prove to be a very serious matter.

The best plan is to call up the powerhouse, if it is practical to do so, and ask the voltage and kind of current; also, if alternating, what cycle.

In this connection let me add that the traveling operator should always consult the powerhouse officials before connecting to lines in small towns, especially if the show is to be given in a church, hall or schoolhouse supplied by a small transformer. The transformer may be already loaded to capacity, as may also the street mains and even the dynamos. If you connect without permission, simply on the say-so of some church or school official or citizen and damage is done you can be compelled to pay for it.

CHEAP EQUIPMENT

As a general proposition it may be said that cheap equipment is very expensive equipment in the end. Except where the use is strictly temporary it seldom or never pays to buy cheap projection apparatus.

The wise manager will keep constantly before him the fact that his energies should be directed first and foremost to the bringing in of every possible penny at the box office, and that if a three hundred dollar projector will, by the added excellence of projection, bring in an added box office revenue of even so much as three dollars per week, as against a projector costing two hundred dollars, then the high-priced machine is emphatically the best investment. He must bear in mind that if one of the lenses is producing poor results, those results will operate to send patronage to some rival house, hence it should be replaced immediately. He should not for one instant forget that his audience pays an admission to his house to see what is spread forth upon his screen, and that the more excellent the performance the greater

number of people who will pay admission—hence the greater will be the revenue of the house.

If an experienced thirty-dollar-a-week operator, working with a three-hundred-dollar projector, can produce results sufficiently superior to those produced by the fifteen dollar operator working with a two hundred dollar projector to bring in an added revenue of, say, even twenty dollars per week, then the thirty-dollar operator and the three-hundred-dollar projector is a good investment. And if the average increased revenue amounts to as much as thirty or more dollars per week (not at all impossible, or even improbable) then the high-priced outfit is indeed a splendid investment.

COLORING INCANDESCENT LAMPS

It is often desirable to color incandescent globes. Red lamps are needed for exit lights and red, blue and green are used for stage effects. To produce the desired colors dissolve one ounce of refined gelatine in one pint of water, and, after bringing it to a boil, add an aniline dye (Diamond dyes are excellent for the purpose), of the color desired, in sufficient quantity to make the liquid very dense in color. Dip the lamps in the solution while it is hot, and after removal let them dry as quickly as possible. Repeated dippings and dryings will make the color on the globe more dense. The lamp may then be dipped in a thin brass lacquer, or, better yet, in formaldehyde, which will render the color waterproof. Incandescent globes may be frosted by dipping them in a strong solution or hydrofluoric acid.

A WARNING

Those who contemplate the erection of new theatres or the remodeling of an old one should be very careful about leaving the location and planning of the operation room entirely to the architect; also it is not wise to leave the selection of a screen or other projection equipment to his judgment.

Consider the question for a moment. *No matter how thoroughly competent an architect may be as to the planning of buildings, by no means does it follow that he has competent knowledge of the requirements of practical projection.*

As a matter of fact some of the very best architects in the country have perpetrated the most atrocious blunders imaginable in operating room construction and location.

It is also, except in isolated cases, where an operator of ex-

ceptionally wide experience is found, not good practice to place operating room construction and equipment in the hands of the operator. He may be a most excellent operator, but his experience is most likely limited to what he has observed in a comparatively small number of theatres.

There are now available a few really competent projection engineers, and I would by all means advise that architects' plans be submitted to one of these men and that they be requested to suggest changes, both in the operating room location and its plans, which suggestions the architect shall be, if necessary, compelled to incorporate into his plans. Remember that the income of your theatre will depend very largely on the result on its screen. Why place that result more or less at the mercy of an architect who, however learned he may be along other lines, knows little or nothing about practical projection? Such a course can but result in the hampering of the work of your operator and the injury to greater or less extent of the picture on your screen.

It would also be an act of wisdom to consult a projection engineer *who has no manufacturing connections* concerning projection apparatus. You or your operator may know something about a few of the hundreds of different kinds of apparatus, but it is the projection engineer's business to have a comprehensive knowledge of them all.

A FEW DOLLARS INVESTED IN EXPERT KNOWLEDGE WILL SAVE YOU MONEY IN THE END, AND AS A GENERAL PROPOSITION THE RETURN WILL BE A THOUSANDFOLD.

Airdomes

During the summer months, particularly in the south, airdomes or open air theatres are very popular, and they are justly popular, too, because they contribute to the the amusement of the people under the best possible conditions as to fresh air, etc. In the past, however, airdome construction has been altogether too crude. In many of the smaller towns it has consisted merely of an open lot with a high fence around it, seats set directly on the ground, a little saw-off "coop" containing one projector, and the cheapest possible kind of screen.

In New York City the law requires, among other things, that airdomes must be floored, either with wood or cement, and that the chairs be fastened thereto. This is an excellent rule to be followed. If it pays to do a thing at all it pays to do it right. A dirt floor is by no means satisfactory, par-

ticularly to women wearing white skirts and good clothing. In very small towns, however, the expense of a cement or lumber floor may be prohibitive. In such cases a floor of tamped cinders will do fairly well, but the layer should not be less than 4 inches thick after being tamped, and the chairs must be fastened together with wooden strips and the sections thus formed fastened securely to stakes into the ground. Except in very small villages, however, if the airdome is designed to be a permanent institution I would by all means advise the installation of a proper floor, and that means one either of lumber or cement, preferably the latter.

The seating of an airdome should be comfortable, but of such character that it will not be seriously affected by sun or rain, since it is exposed to the weather. What is perhaps the most satisfactory seating, everything considered, is a regular theatre chair, but with unveneered, heavy, unpainted but varnished wood backs and seats. Such seats may be had. They are substantial, comfortable, and eminently suited to this kind of installation. It is also quite possible to build a bench with seat having the curves of a regular theatre chair, the seat and back to be covered with three-inch wood strips spaced 3¼ inches center to center. The seat should be divided into 19 or 20 inch spaces. *If this be carefully done, using the back of a theatre chair to get the angle and slope,* the result is quite satisfactory. But if a bench be made without attention to form and without dividing it into individual spaces, the result will be very unsatisfactory. The seat division may consist of an iron rod extending from a point half way between the seat and the top of the back to the front edge of the seat, thus forming a combined division and a very substantial brace. Use half-inch round iron. If smaller, mischievous boys are apt to bend them, and if the divisions be of wood they may be whittled. There are other ways of doing it, but the method suggested is the best. All iron work should be coated with asphaltum paint to prevent rusting. *Whatever the character of the seats, however, they must be securely fastened to the floor. Loose seats are extremely dangerous in case of panic.*

The operating room should be not less than 6 feet wide by 8 feet deep (front and back) if it is to contain one machine, or 8 by 9 if it is to contain two. It should be made of concrete or brick, have an ample vent flue, with inlet air flues near the floor. The ports of the operating room should be the same as for the regular theatre operating room (see Page 216).

The screen should be supported in such manner as will stand the strain of considerable air pressure. If it can be placed against a building, well and good, otherwise there should be timbers not less than 4 by 6 inches, long enough to reach to the top of the screen, and be *set into the ground not less than* 4 *feet*. These timbers should be guyed to the top of suitable anchor posts set into the ground not less than 3 feet and located not less than 10 feet back of the screen. These guys or braces should be of 2 by 6 lumber. Remember *with a heavy wind blowing the screen will develop a lot of pulling force.* The bracing will, however, depend considerably upon the location of the screen—that is to say whether it will receive

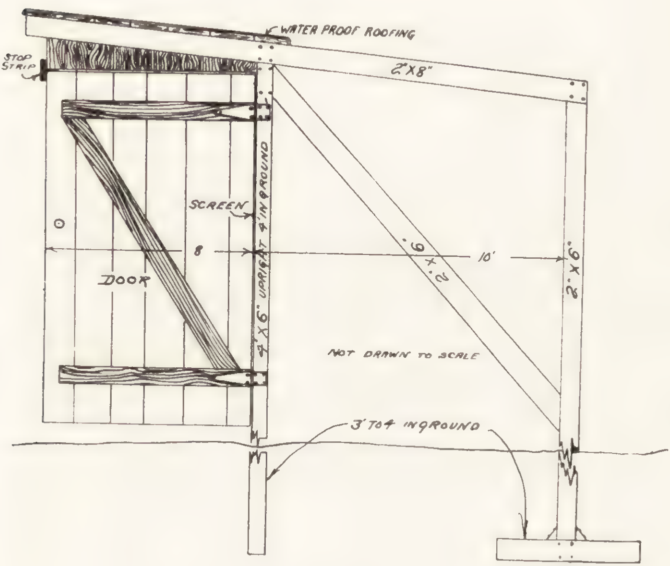


Figure 313.

the full force of the wind or not. If it is protected by buildings or otherwise the bracing and size of uprights may be modified. For the front of the screen after careful consideration I would recommend the following: that there be a hood

extending outward from the top of the screen not less than 8 and preferably 10 feet, to extend out at an angle beyond the sides of the screen to meet two wings hinged to the edge of the screen and so arranged that they may be closed when the performance is over, the idea being to combine two screen-protection doors and an upper apron into a hood, the inside of which should be painted dead black. The hood above can easily be supported by means of wooden timbers extending out back and anchored to the anchor posts holding the top of the screen.

The whole plan is shown in Figs. 313 and 314, in which we are presumed to be looking at the edge of the screen. The top of this hood should be roofed with some one of the patent roofings so that it will be water tight. There is nothing at all impracticable in this plan, and such a screen, by thoroughly shading from moonlight, etc., would add very greatly to the beauty of the picture in any airdome, and would enable the operator to show a good picture on the brightest moonlight night, practically regardless of the direction of the moon; also it would enable the use of one of the metallic surface screens without fear of deterioration, since it would always be protected.

I believe the two illustrations will enable you to understand my idea in the construction of the screen. Fig. 314 is a front view of the screen.

For an unprotected screen surface I would suggest wooden lath on a substantial backing, braced as before suggested, and plastered with two coats of very strong cement mortar, with a finishing coat of cement mixed half cement and half sand. This surface should then be covered with about three coats of paint mixed as follows: White lead ground in oil mixed with boiled linseed oil and a little Japan dryer for the first coat. White lead ground in oil mixed with one-half boiled linseed oil and one-half turpentine for the second coat. White lead ground in oil mixed with one-third boiled linseed oil and two-thirds turpentine for the last coat. Light space to be outlined in black (see Page 179).

Selecting a Site.—Briefly the items to be observed in the selection of a site for airdomes are as follows: (a) Does the ground lie right? Is the lay of the ground adapted to use as a theatre auditorium floor, or will you have to do a lot of grading? (b) Will it be necessary to erect a high fence all around the site, or is a portion or all of it already taken care of by billboards or walls of other character? (c) Will the

glare of the lights and noise or the sound of music call forth protest from surrounding property owners? (d) Does the site adjoin a large tenement house, or other buildings from which a good view of the show may be obtained without the for-

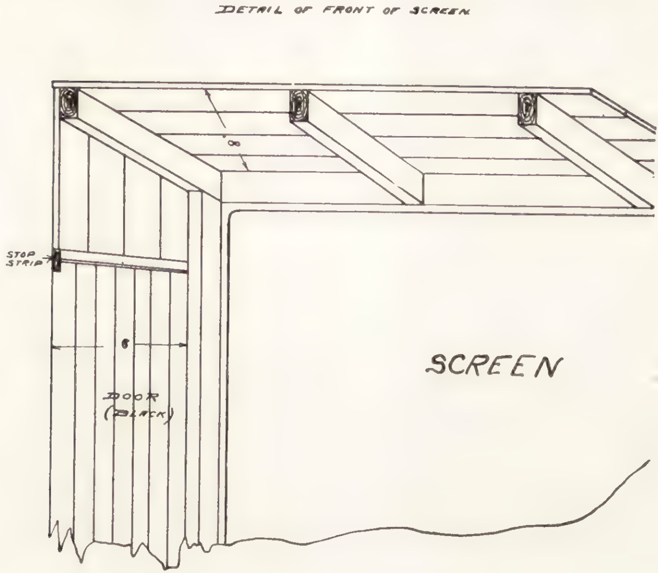


Figure 314.

mality of paying admission? (e) Will it be necessary to secure signatures of adjoining property owners in order to get a license? If so, can this be done? (f) What will be the probable patronage, as judged by character of surrounding neighborhood, and the density of its population?

The builder of an airdome should consider that where practical it is always best to have the screen face the north or east, since with the screen facing either of those directions it is possible to begin the show anywhere from twenty minutes to an hour sooner than would be practical if the screen faced the south or west. Never have your screen face the west if it is possible to avoid it, unless the light from the west is cut off by some high building or obstruction. The builder of an airdome will do well to consider other points

applying only to certain localities. For instance: How about mosquitoes? It is rather a questionable proceeding to build an airdome in a mosquito infested district.

Projection by Limelight

WHAT is known as "Limelight" is produced by directing the flame of hydrogen mixed with oxygen against a pencil of unslacked lime, or a pencil of a substance know as "Guil Pastil." The flame in itself has slight brilliancy, but is exceedingly hot, and raises the temperature of a spot on the lime or pastil to incandescence, and it is from this spot all illumination emanates.

While limelight is next to electricity in brilliance, still it cannot be said to approch the electric arc for moving picture projection, although it may be made to serve very well for stereopticon work.

Those who by force of circumstances are compelled to project moving pictures with limelight will be well advised to select films of the least possible density and not attempt the projection of a large picture. The writer considers it unwise to attempt more than a ten-foot picture with limelight, and an eight foot one is much better. True, some do project a twelve-footer, but illumination is not very good. The amateur had better not try more than eight feet.

Tank Gas.—The best method of producing limelight is by purchasing the oxygen and hydrogen in tanks. Companies in large cities make a business of filling steel tanks with these gases and selling them, or rather the gas in them to exhibitors, the price ranging from 10 to 15 cents per cubic foot. The oxygen tanks are painted red and the hydrogen tanks black. The tanks are usually loaned to the exhibitor free of rental, the exhibitor making a suitable cash deposit to insure their return. Usually tanks may be had in two sizes, viz:, one containing 25 and one containing 50 cubic feet. The two sizes weigh about 50 and 100 pounds respectively. They are shipped by express, and if the distance be long the shipping charge may make the gas very expensive. A pair of 25-foot tanks should by reasonably economical management last for about three ordinary shows and the larger ones for six shows. This will, however, depend on the length of show, size of burner jet and skill of the operator. Assuming five ordinary reels of film, many operators are satisfied to get two shows from the 25-footers and four from the fifties.

Tank gas is, counting shipping charges, usually more expensive than gas made with a good portable outfit, but it is superior in quality and much more convenient.

The gas is under high pressure (250 pounds per square inch; some small cylinders are charged at far greater pressure) and may be, but should never be used without a "reducing valve." A reducing valve may be had of any dealer in limelight supplies, and should be a part of each limelight user's outfit. It is also well to have a pressure gauge for each tank. Some use low pressure gauges to show pressure after gas has passed the reducing valves, though this is, I think, rather "fussy" and quite unnecessary. The tank gauges are not absolutely necessary, but are nevertheless very convenient.

It is advisable to have red hose for the oxygen connections. The other may be any color, but preferably black. This is to prevent making mistakes in connection, which might cause considerable annoyance, or worse.

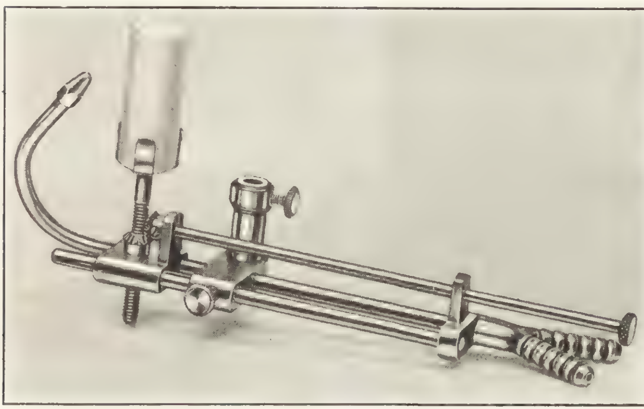


Figure 315.

In Fig. 315 we see a typical burner for the mixing of oxygen and hydrogen to produce limelight. The lime sets on end in the three prong holder as shown.

Gas Making Outfits.—There are a number of outfits for making gas for limelight on the market. Among the best of these is the Model B, made by the Enterprise Optical Company, Chicago, full description of which may be had by addressing the company.

In this connection the following letter taken from the Projection Department of *The Moving Picture World,* July 5, 1913, is of sufficient value to warrant receiving space. The letter is from Mr. George A. Kraus, Magollan, New Mexico. Mr. Kraus says:

"My own experience with gas-making outfits, after having tried every American make, as well as one outfit imported from England, is that the Model B Calcium Gas Machine, manufactured by the Enterprise Optical Company, Chicago, is the lightest and most simple in operation. It can be set up and charged, ready for use in from five to ten minutes. There is never more than one pound pressure on the machine. When in use the water in the upper tank regulates the gas. So long as one uses the gas generated, the water in the upper tank lowers to the lower one, generating gas as needed. The moment you shut off the gas the machine stops generating. After the show, drain off the water and take off the standpipe. Should there be any oxone left over, it can be used again the next time the machine is charged. I have run three continuous shows, of three reels each, with one charge of 30 cakes of oxone, but the saturator has to be recharged after every performance. I have two saturators connected with the standpipe of one, which gives sufficient hydrogen for the three shows without recharging. I project a 12-foot picture at 41 feet, using my Model B gas machine, and get plenty of light. For road work or permanent location the Model B could not be too highly recommended."

It is not my purpose to give directions for the operation of these outfits, as full and very complete directions accompany them when purchased. Suffice to say they are all quite practical, reasonably simple in operation, and capable of producing a very good light, at a cost which is not very much different from the cost of tank gas, when distances of shipment of tanks is averaged, always provided they be handled with intelligence, be kept scrupulously clean, and that *the directions supplied by the manufacturers be explicitly followed.*

Don't imagine you can produce good limelight by careless, sloppy methods. It simply can't be done. The illumination is a comparatively weak one at best, and good results are hard to get (for moving picture projection) under the best conditions. This is all the more reason why the limelight user should exercise every care to get every possible bit of light brilliancy his outfit is capable of producing.

The gasmaking outfits make the gas as it is used. This is accomplished by the use of sodium peroxide, which, when properly prepared and brought into contact with water, gives off approximately 300 times its own bulk in oxone. The sodium peroxide is made into cakes and is usually sold under the trade name "Oxone," though some manufacturers use other trade names, one of which is "oxylithe." These cakes are placed in a reservoir, which forms the greater part of the gas making machine, and water is added, which causes the

formation of oxygen the instant it touches the "oxone." The water supply is usually so arranged that the water, by its weight, forms a pressure of air in the reservoir, and this pressure prevents it reaching the oxone, which is arranged somewhat as per Fig. 316. When the gasburner is opened some of the air escapes, which allows the water to rise and touch the cakes of sodium peroxide (oxone), whereupon gas is formed, the pressure increased, and the water again driven down until enough gas is used to decrease the pressure, and again allow it to rise and touch the cakes, thus releasing a new supply of gas, and so on until the cakes are entirely exhausted, whereupon the reservoir must be opened, cleaned, and a new supply of cakes and water put in. It is, of course, very essential that the reservoir be absolutely gas tight.

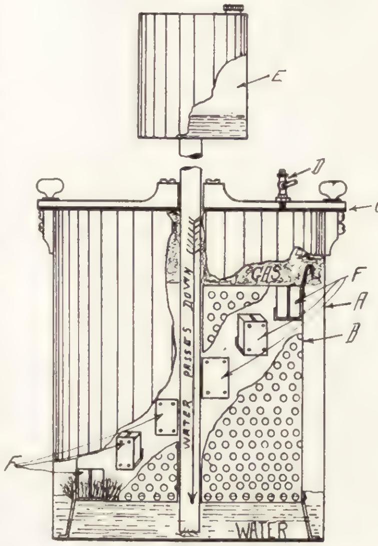


Figure 316.

When the oxygen has been formed it may be combined with ether, or with high grade gasoline. This is accomplished in a part of the machine called the "Saturator." When the oxygen leaves the reservoir a portion enters a tube and is led directly to the burner. Another portion is led through a tube to the saturator, in which is a pad, usually made of flannel, saturated with ether, or high grade gasoline. The oxygen passes through the saturator, and is there loaded with ether or gasoline (as the case may be) vapor, which makes it inflammable, and enables it to act as a substitute for hydrogen.

Caution: In warm weather, and when the saturator is nearly full, very little oxygen is required to vaporize the ether, and there is less danger of explosion (popping and snapping) than when the saturator is nearly empty or when it is very cold.

The foregoing is merely intended to set forth the principle

of operation of these outfits. Still another plan, followed by some, is to purchase oxygen in tanks and combine it with ordinary illuminating (coal gas) gas from the gaslight system. When this is done, due to the very low pressure of the illuminating gas as compared to that of the oxygen in the tank, it is advisable, and even necessary to have a special form of mixing jet for the lamp. What is known as the "blow-through" jet (to be had of any dealer in limelight supplies) is usually employed for this kind of work. This jet is illustrated in Fig. 317. The use of the oxygen-illuminating gas combination is not to be recommended for amateurs.

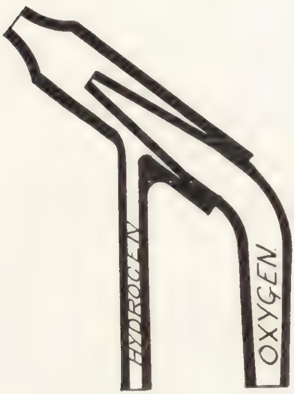


Figure 317.

Limes.—Limes may be had in several sizes, up to 1¼ inches in diameter. The largest size is not the best, however, because it is apt to flake off or even break under the action of heat. A one-inch lime is preferred by most operators, though some use seven-eighths inch.

Limes come in sealed cans or jars, packed in powdered lime. *They must not be removed from the package until needed, and the package must be kept sealed.* If exposed to air containing moisture the limes will slack, or if there be no moisture then they will become hard and unfit for use. Limes are quite fragile and easily broken.

Limes must be placed in the burner so that they will stand perfectly straight and not wobble even the least bit when revolved. If not set true there will be uneven illumination of the screen as the lime is revolved during the progress of the show, to expose a new surface to the flame. The unevenness will be due to varying distance of the lime from the tip of the burner.

Starting the Light.—Starting the light is an operation which, while simple, requires the exercise of considerable care. Having placed the lime in position in the lamp, or burner, as it is usually called, and turned it up so that it does not "wobble" when rotated, pull the lime away from the burner tip from one-half to one inch, and, having turned on

the hydrogen, light it at the burner-tip with a match, just as you would light an ordinary gas jet.

Caution: *If using tank gas, remember it is under heavy pressure, and, if there is no reducing valve, open the tank valve very carefully.*

Turn on sufficient hydrogen to make a flame two, three, or four inches long (only an experiment can determine the proper length of hydrogen flame, as it will vary with size of tip, with different lots of gas and with the individual operator's ideas) and, while slowly rotating the lime allow the flame to play on it until well heated. This is very necessary, particularly with a new lime and with lime of the larger diameters, since if the full strength of the oxygen-hydrogen flame be concentrated on a spot on a cold lime the latter is very apt to crack. When the lime is thoroughly warmed, advance it to within about one-eighth inch of the burner tip, and then, without altering the hydrogen flame, carefully and very slowly turn on the oxygen gas. The flame will at once diminish in size, and a spot on the lime will become incandescent. Keep turning on oxygen very slowly, until there is a slight hissing, whereupon ease off on the oxygen just a trifle until the hissing barely stops. Some operators prefer their light at a point where it does hiss just a trifle, but I think more light is had just at the point when hissing is about to begin.

The beginner may now, without any film in, projecting the clear, white light to the screen, turn just a little more hydrogen, and again bring the light to the hissing point by adding oxygen. If the screen brilliance is increased, continue the process until there is no further gain. If, on the other hand, the screen brilliancy is less, then try reducing the mixture by *first* shutting off a little *oxygen,* and then a little hydrogen. Keep this up until you find exactly what mixture gives the greatest screen brilliancy, whereupon *shut off the oxygen* and carefully note length of hydrogen flame. Having done this you will be able to tell pretty closely what length of hydrogen flame will give best results, which will be a help every time you start the light thereafter.

Some operators turn on oxygen until a slight red fringe appears at the top of the spot on the lime. I cannot recommend this method, however, as being very accurate.

When turning on the oxygen, if the light should go out with a loud snap, or popping sound, quickly *turn off the oxygen,* relight the hydrogen with a match, and again slowly turn on the oxygen. See "Popping" or "Snapping," Page 680.

Caution: Remember when handling limelight gases that oxygen and hydrogen form an explosive mixture *when combined. Always turn the hydrogen on first and off last.* That is to say, when lighting up *never* turn the oxygen on until the hydrogen has been lighted, and when shuting down *always turn off the oxygen first.* Failure to pay heed to this may result in damage to the apparatus. Under certain conditions it might even cause a rather serious explosion, though that is extremely unlikely.

Distance of Jet from Lime.—The best distance of tip of burner jet from the lime will vary slightly with size of jet and mixture used. Test the matter as follows: After the light has been burning long enough to have its normal illumination, project the clear, white light to the screen, and, first making sure there is no pit in the lime, slowly move the jet ahead and back until the point of maximum illumination is found.

If the tip be too close to the lime its point may be melted. The tip must be closer with a soft lime than with a hard one.

"Popping" or "Snapping."—Popping or snapping out of the light is one of the most annoying things the limelight operator has to contend with. It is seldom or never dangerous, except to the hose connections.

When the light snaps out turn off the hydrogen quickly, else the flame may back up in the tube and melt the rubber, or even the metal connection at the hydrogen tank, the reducing valve or the saturator. This only holds good when using a gas making outfit in which oxygen passes through the saturator.

Popping or snapping (interchangeable terms meaning the same thing) is usually due to excess of oxygen gas. Remedy: Reduce the oxygen. It may also sometimes be traced (though seldom) to the tip being too close to the lime. Popping is in reality a miniature explosion, and sometimes splits the rubber tubing used for connections. For this reason

It is best to use flexible, metal-covered tubing, which may be had of any department store or dealer in gas fixtures. It costs but a few cents per foot. Paint the one used for oxygen bright red, to prevent errors in making connections.

Light Goes Out.—If your light just simply "goes out," without making any noise, it may be due to (a) leaky or split tube, (b) cracked or broken lime, (c) tube slipped off connection (should be wired on); (d) gas supply exhausted; (e) valve clogged. The remedy for these conditions is in each case obvious.

Revolving Lime.— The action of the flame on the lime is

to form a depression on its face, called a "Pit." As this pit has the effect of altering the distance of the lime from the burner tip, it affects the light brilliancy, and it is necessary occasionally (time varies between two and five minutes, depending on hardness of lime and force of gas jet) to revolve the lime just enough to move the pit out from in front of the jet and present a new surface to the flame. In doing this *revolve the lime very slowly,* so that the new surface will have time to come up to incandescence as the old one cools off, else you will produce a decidedly bad effect on the screen.

Hissing or Roaring.—Some operators supply their jet enough oxygen to cause the light to hiss very slightly. Should there be a loud hissing (some call it "roaring") it may be due to (a) Excess of oxygen, in which case the light is apt suddenly to go out with a loud pop, or snap. If this occurs turn off oxygen *quickly* (see "Popping or Snapping") relight the hydrogen and again turn on the oxygen. (b) Interior wall of burner jet rough. Remedy: New jet. (c) Too much gas for size of jet. Remedy: Reduce gas. (d) Wrong distance between tip of burner and lime. Remedy: Alter distance. A deep pit in lime has this effect, and if the lamp begins to hiss, without any adjustment having been altered, the probable cause is a deep pit, and revolving the lime will remedy matters.

Adjusting the Lamp.—The light must be centered with the condenser, precisely as in the case of the electric arc. If it be too far away, too close, too high, too low or too far to one side, the screen illumination will be uneven, and there will be shadows. By means of the adjustments provided, move your lamp up, down or sidewise until the screen is evenly illuminated all over, and there is no trace of shadow.

The Condenser.—The condenser used for limelight is the same as for the electric arc. It is customary to carry the spot a trifle larger than with electricity, due to excessive area of light source with consequent "fuzzy" edges of spot at cooling plate and use two 6½ lenses, located as close to the aperture as they can get them. Whether or not this is the best practice I am not prepared to say, but presume it is, as it is much used. One operator even advises altering the outfit, if necessary, so as to get the lamphouse cone right up against the machine aperture, shoving it to one side to change films. This does not seem to the author like good practice, but try it out anyhow. I would suppose this closeness would require the locating of the light too far from the

lens, which would mean heavy loss of light. This is, however, only my impression. I have not actually tried it out. I should think a 5½ lens next the arc would be better under those conditions.

Objective Lens.—*Never use an objective lens of small diameter for limelight projection.* Be certain the lens diameter is large enough to receive the entire light ray (see Page 110). You have a comparatively weak illuminant at best, and cannot afford to waste any of it. Three and one-half, 4 and 4½-inch E. F. objectives are popular with gas users. An eight-foot picture at 40 feet seems to be the one best liked. A 3½-inch will give close to an eight-foot picture at 30 feet, and a 4½-inch will give a little more than an eight-foot picture at 40 feet.

Clean Lenses.—Clean lenses are extremely important when using limelight. A dirty lens wastes much light by reflection, and you cannot afford to waste any of your light when using limelight. See "Cleaning Lenses," Page 108.

Fitting the Limelight Burner into a motion picture projection lamphouse will in the newer models of projectors call for a new lamppost, since, while the lamppost used for some of the old style, small arc lamps will serve also as a support for the limelight burner, the lamppost of the newer, heavier arc lamps cannot be used for the purpose. The method of anchoring the new post into place will vary with different makes of projector, and must be left to the ingenuity of the operator. Be sure, however, and get it located so that the backward and forward adjustment of the arc lamp base will still answer its purpose in the forward and back adjustment of the light with relation to the lens.

Machine Shutter.—It is never wise to use a three-wing revolving shutter with limelight. It cuts too much light, and with such a weak illuminant the flicker is not sufficient to require the three wings. Use a two-winger, with the blades reduced in width as much as is possible and avoid travel ghost. (See "The Shutter," Page 469.) It is even claimed by some operators that, when using oxygen and hydrogen with a lime pencil, they get excellent results with a one-wing shutter. I cannot vouch for this. In fact I am just a little bit skeptical, but it is nevertheless worth trying. Remove your regular shutter blade from its hub, cut a single block from stiff but thin cardboard, using the main shutter blade for a pattern, and substitute for the regular shutter blade. If you find it works satisfactorily insert a metal blade in place of the pasteboard. This cannot be recommended

where a guil pastil, ozo-carbi, or Bliss Oxy-Hydro-Cet Light is used, as the illuminant is too bright. When trying out the one-wing shutter idea, it will be well to run the machine a little above normal speed. The gain in light will compensate for a *slight* flicker and some injury to the action in the film. The reason a one-wing shutter may possibly be used for limelight projection is that flicker is very much less pronounced with a weak illuminant than with a bright one. It is a matter of screen brilliance.

Screen.—For limelight I would by all means advise one of the best semi-reflecting screens obtainable. If a muslin or plaster screen is used be sure it is perfectly clean and white. A Mirror screen would be ideal, but is too costly to be considered for a gas installation. Outline your picture in black (see Page 178) and *have the room as dark as you can possibly get it.* This is especially important when using a comparatively weak illuminant.

Guil Pastil.—Guil Pastil is the invention of one M. Guilbert, a Frenchman. It was first imported into the United States, in 1913, by C. E. Lindall, Bar Harbor, Me. Mr. Lindall submitted samples to the Projection Department of *The Moving Picture World,* which had them tested by practical gas men, who, without exception, reported favorably. The pastil is unquestionably a big improvement over the lime, for which it is a substitute. It is made of thorium, ittrium and other rare earths, found mostly in South America. Instead of setting upright in the burner it is held in horizontal position, the jet playing on its end. It does not need to be revolved, as does the lime, and once adjusted should not be moved. Its density is such that little or no pit is formed by the jet. It comes in different sizes, but the largest, ¾ by 13/16 inch, is most popular with operators, and is the size recommended by the importer. The pastil is not affected by dampness, but, owing to its density and the fact that is is a very poor conductor of heat, is very brittle, and *must be heated very slowly, else small pieces are apt to snap off, thus injuring the pastil.*

The hydrogen will often blacken the pastil while heating, but this does no harm, since as soon as the oxygen is turned on the blackness disappears. If preferred blackening may be avoided by pulling the pastil away from the tip until the light has been adjusted to about what experience tells the operator it should be, and then the pastil slowly advanced to its normal position. Do the advancing very slowly, however, or you may injure the pastil.

American-Made Pastil.—During the European war it was for a time impossible to obtain French pastil, so Mr. Lindall got busy and produced an article which some operators pronounce superior, many just as good, and a few not so good as the foreign article. As to quality, each man must compare and judge for himself. Mr. Lindall says the ingredients, density, etc., of the "home grown" article are identical with the French product. Personally, I believe the Lindall article is practically as good as the French.

The following is reproduced from the Projection Department of the *Moving Picture World,* June 13, 1914. It contains valuable data for pastil users.

"After a three months' trial, under various and severe tests, I have finally discarded the old, faithful lime pencil, for the reason that since using the guil pastil not only are the general results better, but my gas consumption has been reduced by fully one-third. While I formally consumed twelve cakes of oxone, with guil pastil eight suffices for a one and a half-hour entertainment. I now have a pastil in my lamp which has been used for twelve consecutive shows, and it is still good for ten or twelve more. With careful handling the guil pastil should, in my opinion, average at least eighteen entertainments, each one and a half hours in length. But great care is necessary in handling the pastil, since it is very fragile and will not stand up under rough treatment as will the lime pencil. The first two pastils I tried lasted but one show each. I had been using lime pencils for several years, and one can shove in a lime pencil at a moment's notice, turn on both gases as soon as it is in place, and be ready to begin the show. I tried this method with the pastil, with the result that it heated too quickly and cracked, and by the time the last reel was through the pastil was on the floor of the lamphouse in small pieces. I now first turn a small flame of hydrogen for about three minutes, which heats the pastil slowly and thoroughly; then I turn on the oxygen gas slowly, until there is a small red ring on the outside of the flame. This heats the surface of the pastil to white heat, delivering a steady, powerful, white light which the line pencil can never produce. The pastil throws a brilliant, clear field like an electric arc, except, of course, it is not so powerful a light. To get the best result with the least consumption of gas, have the burner-tip at the lower edge of the pastil and about one-eighth of an inch away from it. At this distance the gas is evenly distributed over the surface of the pastil, so that its outer edge is as white as the center. If the tip be any closer than this the light will be in the center and the edges will be darker, which makes for poor results, besides pitting the pastil in the center, due to the blast of gas which concentrates on one small spot. I get the best results from a nine-sixteenths size pastil, using two 6½ condensers, projecting a 12-foot picture at 45 feet."

Repairing Guil Pastil.—Should a guil pastil by accident be broken it may be repaired and made practically as good as new as follows:

Take some soft asbestos wicking, such as is used for packing the stems of steam valves (to be had at almost any hardware store) and wrap some of it outside of the pastil, as per Fig. 318. Then over the asbestos wind some soft wrapping wire, such as jewelers use. Now make a band, or

clamp, Fig. 318, out of a heavy piece of sheet metal or tin. Bend this metal band into shape so it will act as a sort of shield and then push it down over the pastil and holder. I would recommend that new pastils be treated in this manner. It protects the pastil from damage and is worth while merely as a matter of protection. By its use you will be enabled to turn off the gas without being so careful about it. The heat will burn off the wire as fast as the pencil is consumed, so that all one needs to do is to smooth the surface of the pencil occasionally with a piece of No. 00 sandpaper.

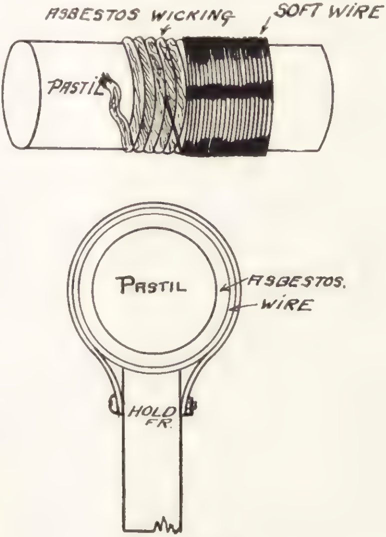


Figure 318.

The S. A. Bliss Oxy-Hydro-Cet.—S. A. Bliss, Peoria, Ill., has perfected a limelight which many operators commend highly. It consists of commercial oxygen, the same as is ordinarily used, and a substitute for straight hydrogen, consisting of hydrogen combined with gas from calcium carbide, and gasoline vapor. A specially constructed burner is supplied by the Bliss Company. By this process it is claimed that back firing, popping and snapping is entirely eliminated. The apparatus consists of a hydro-cet generator and a special burner. Oxygen may be generated from "oxone" in the usual way or purchased in tanks. Full directions accompany the outfit. The light produced is more brilliant than that produced by the ordinary oxygen-hydrogen gas. It may be used either with lime or guil pastil.

I am informed that Mr. Bliss has secured a special price of 2 cents per cubic foot on oxygen gas to be supplied to his customers. This price is made by a large firm having plants in thirty-three of the largest cities in the United States.

Ozo-Carbi.—This light (Patents 393,737 and 724,416) is

made by burning carbide or acetylene gas with a compound gas, which is really a modified form of oxygen, called "Ozo." Two tanks are used, one for the carbide and one for the ozo gas. Each gas is made by the operator before the entertainment, and is stored in the tanks. It is then used with the ordinary calcium burner, just the same as you would use the regular tank gas, and there is no more danger in its use than there is in using oxygen and hydrogen such as is sold in tanks.

Acetylene and oxygen produce a very high degree of heat —in fact, the highest degree possible to obtain, other than that of the electric arc. It is not, however, practical to burn them together in a calcium jet, but acetylene, or carbide gas will burn together with the Ozo gas in a calcium jet, the same as oxygen and hydrogen gas, but the result is a higher degree of heat, and hence a higher degree of incandescence of the spot on the lime.

The manufacturer claims that the expense of producing the light is very much less than that of producing light by means of oxone combined with ether or gasoline. He also claims a considerably higher illumination.

For myself I can vouch for the fact that the ozo-carbi forms an excellent illuminant and that it has many apparently well satisfied users among gas men. Full and complete instructions accompany each outfit.

THE END

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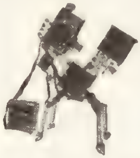

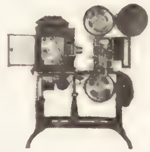

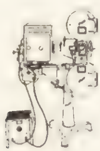

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